ST. MARY'S UNIVERSITY GRADUATE SCHOOL

INSTITUTE OF QUALITY AND PRODUCTIVITY MANAGEMENT

WASTE MINIMIZATION THROUGH QUALITY IMPROVEMENT TOOLS

(THE CASE OF BERHANENA SELAM PRINTING ENTERPRISE)

BY: ENDALE MULUGETA

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July, 2021

Addis Ababa Ethiopia

A THESIS SUBMITTED TO ST. MARRY'S UNIVERSITY, SCHOOL OF GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN QUALITY AND PRODUCTIVITY MANAGEMENT

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APPROVED BY THE BOARD OF EXAMINERS

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Advisor	Signature	Date
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Internal Examiner.	Signature	Date

DECLARATION

I declare that this thesis is my original work, prepared under the guidance of AMARE MATEBU(PhD). All sources of material used for the thesis have been properly acknowledged. I further confirm that the thesis has not been submitted either in part or in full to any other higher learning institution for earning degree.

ENDALE MULUGETA

Signature _____

July, 2021

St. Mary University, Addis Ababa

ENDORSEMENT

This thesis has been submitted to St. Mary's University, School of graduate studies for examination with my approval as a university advisor.

Advisor _____

Signature _____

July, 2021

St. Mary University, Addis Ababa.

ACKNOWLEDGEMENTS

First and for most, I am grateful to God almighty for successful completion of this study. Next to God I wish to express my deep and sincere gratitude to my funding company owner of SUPER DOUBLE T GENERAL TRADING ATO STEGAYE DEBEBE AND his wife WEYZERO TIGIST GETNET and with their family for giving me this golden opportunity to study this program and for their inspiring guidance, constructive and valuable suggestions throughout the school time. I would like to express my deeper thanks to all my brother and the rest of family.

I am also thankful to my Advisor AMARE MATEBU (PHD) for his motivated and inspiring comment for successful completion and also I want to thank Berhanena ena selam printing enterprise managers and workers for their cooperation and finally I want to thank St. Mary's University, School of Graduates Study, who have designed and provided this opportunity to preparing this paper and study for a MSC program.

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List of Acronyms

RCA .....Root Cause Analysis

OOR.....Out of Roundness

WM.....waste minimization

BSPE.....Berhanena Selam Printing Enterprise

ABSTRACT

Obviously, today´s competitive environment has changed the mindset of printing industry, which activated to concentrate towards waste minimization as a crucial issue in the printing industry.This study aims at assessing the type of wastes prevailing and identify their root causes at Birhanena Selam printing enterprise. Both qualitative and quantitative methods of data collection were used. And also, Reviewing documents and Interviews methods were applied to collect data. All of the workers in the printing department were included in the study and The total population of the study was 32. the findings of the study revealed that the types of wastes in the printing enterprise were newspaper waste, tear-off waste, Reel-end waste, and sweeping waste". It also revealed that during the study period the average waste excreted in the department were 9574 kg/month. In addition, the findings revealed the large amount of waste was newspaper waste which accounts about 44.9%. Data analysis was carried out using quality improvement Tools. After Pareto Analysis, it was found that News-paper waste is the major contributor to the printing paper waste. In order to know the causes leading to News-paper waste, a Cause and Effect Diagram was prepared using brainstorming and preparing Questionnaires for the respondents which helped in locating the major causes. Ideas were generated to improve the process and reduce the news-paper waste in all categories.

Keywords: Pareto Analysis and Cause & effect diagram

CHAPTER ONE

INTRODUCTION

This chapter consists of background of the study, statement of the problem, research questions, general and specific objective of the study, significance of the study and scope of the study of the thesis presented.

1.1 Background of the study

Traditionally, waste is viewed as an unnecessary element arising from the activities of any industry. In reality, waste is a misplaced resource, existing at a wrong place at a wrong time. However, much of today's natural resources are used in an unsustainable manner and end up as waste. Using excess raw materials, poor resource utilization, scrap parts and outdated materials all contribute to organizations waste streams and take a loss on both the environment and the finances of a company *(Franchetti, 2009).*

To face these problems and approach sustainable development, quality improvement tools and methods are crucial. In the printing industry pressures to adopt more sustainable practices have become increasingly important because of, among other things, customer and legislative demands to lower the environmental impact of its activities. Today printers face pressures to reduce costs due to worldwide overcapacity and rising costs of raw material and energy *(Thompson, 2014).* By using resources more efficiently and reducing wastes, printing companies can increase their chance of maintaining their position in an increasingly fierce market environment *(Envirowise, 2004)*

Globally, printing industry is the largest consumer of paper product and estimated over a trillion paper are used for printing annually across a country. As printing industry continues minimize waste and improve the quality of paper is very crucial. Focusing on root causes of wastes and taking possible course of action like quality improvement tools results reduce costs, maximize efficiency, and become effectively use resources. Therefore, it is essential and helpful to define and classified waste with respect to printing industry. Hence, **what is waste?** Waste is nothing but it is something lying unproductive, inhabited, or desolate and Waste (or wastes) are unwanted or unusable materials. Waste

is any substance which is discarded after primary use, or is worthless, defective and of no use. *(Global paper industry - Statics and facts)*

Now a day, printing industry uses various printing technologies for printing books, magazine, newspapers, business documents, catalogues, form, etc. These technologies include lithography, rotogravure, flexography, screen, letter-press, and digital technologies including inkjet and electro-photography. The use of these technologies depends on the required quality of the print, number of impressions to be printed, availability of required resources, cost of the equipment, consumables cost per unit, need to use variable content, and other factor. Printing process requires various fundamental printing technologies. Raw materials and chemicals used in production generate or become wastes. When the waste generated causes financial loss to a company and poses a threat to the environment-air, water, and land, then it becomes a problem to society at large. The waste emerging in production process of printing system should be studied, categorized and treated according to an appropriate quality improvement methodologies and procedures (*Pelin Hayta and Mehmet Oktav 2019).*

Waste minimization through appropriate quality improvement tools which is vital to the growth and development of printing houses in Ethiopia cannot give a special focus or concerned. In order to run a printing house as efficiently and economically as possible, one should minimize all types of wastes existing in the printing industry. The waste emerging in production process of printing system should be studied, categorized and treated according to an appropriate quality improvement tools and procedures. Waste generation is inevitable in printing industry. All the printing processes, namely, offset lithographic printing, gravure printing, flexography/letterpress, and screen printing use materials and chemicals that generate waste. When the waste generated causes financial loss to a company and poses a threat to the environment-air, water, and land, then it becomes a problem to society at large.

1.2. Problem statement

The demand of Ethiopian printing and publishing industry is increasing from time to time, due to the population growth and dramatic expansion of education and business environment in the country. Currently, the printing companies are not satisfying the local

demand, this is indicated with the speed, quality, and underutilization of production capacity of most publishing companies. The printing industry is also challenged with regard to effective management strategies especially in waste management, technology investment, and cost of printing and publishing

There is a huge market for the printing products in the country with the prevailing economic situation, but the industry has its own challenges. These include improper utilization of resources, improper waste management, shortage of trained manpower especially lacks of specialized institute on printing technology, foreign currency shortage for international purchase of raw materials and machinery.

The printing industry is a chemical-intensive industry that produce many types of waste. The waste comes from varieties of activities such as platemaking, image processing, printing, and finishing. some of the waste classified as hazardous by federal or state regulations; other, though not necessarily hazardous, can nevertheless be damaging to the environment if not handled properly; and all require proper treatment and/or disposal at significant cost to the business. Whatever the nature and characteristics of the waste may be, it all has one thing in common: All waste represents loss of resources and loss of money. *(Delaware Department of Natural Resources and Environmental Control, December 1996).*

Berhanena Selam Printing Enterprise was established with the consent of Leul Ras Teferi in December 1924 in Addis Ababa. When it started printing of the first newspaper called 'Berhanena Selam '(Light and peace), the name 'Berhanena Selam 'for the present printing press was adopted from this newspaper. *(BSPE profile).* The problem of waste minimization in the printing industry in Ethiopia particularly in Berhanena selam printing enterprise cannot be over emphasized. Based on the information that gained from majority of workers, the problem of waste minimization had been discussed in workshops and seminars but no one gives such concern to put in real ground. Major wastes created in the Berhanena selam printing was enormous-a lot of papers, inks, darkroom chemicals, films, and plates. The practice has become a normal trend for the employees and management of these printing houses, without realizing the effect waste poses on the customers, the company, the environment, and the surrounding society as a whole. The

quantity of waste created affects the production cost, and its disposal poses a threat to the environment.

Currently, based on annually report of case company there are high costs associated with the generated paper waste, indicated by significance differences between the amounts of purchased raw material (from foreign countries) compared with the amount of paper utilized in the final products. a huge amount of waste paper is accumulated in big houses and burned this results disturbing the environment, and surrounding buildings like ministry of education and other service organizations. Amount of printing waste differ between departments, waste types, and printing processes. The main factors influencing printing waste include: a difficulty of accurately assessing the root causes of waste, lack of attention on waste minimization, missing accountability for waste generation, and a trend where waste is seen as an opportunity.

Therefore, this research paper is specifically more emphasized on investigation of potential causes of the current existing printing wastes under the pre-printing, during process printing and Post-printing steps or strides. Consequently, the most effective way to minimize the losses associated with wastes in printing industry is Quality improvement tools and methods that is helpful to minimize and control paper wastes and any other unnecessary occurrences of defects, and then increase profitability and competitiveness. Among various quality improvement tools and methods in this research paper Root Cause Analysis is selected as quality improvement method with quality improvement tools such as Brainstorming, Pareto analysis, cause and effect diagram and flow charts. One of the reason to select Root Cause Analysis is Many times we may believe that the source of waste is resolved but in reality we have just addressed a symptom of the problem and not the actual root cause. Properly applied, a Root Cause Analysis can identify the main source of waste, failure or defects and determine how to prevent it from happening again. so that understanding quality problems in printing enterprise improve efficiency of using resources and reduce the cost.

1.3 Research Questions

1. What are the main waste types in the printing department of the company?
2. What are the root causes of printing waste generation at the company?
3. What actions need to be taken by the company in order to reduce the identified paper waste?

1.4 objectives of the study

1.4.1. General objective

- To minimize waste through quality improvement tools in case of Berhanena Selam printing enterprise, Addis Ababa, Ethiopia 2021.

1.4.2. Specific objective

- Assess major types of wastes in Berhanena Selam printing enterprise, Addis Ababa, Ethiopia 2021.
- Identify the root causes of wastes in Berhanena Selam printing enterprise, Addis Ababa, Ethiopia 2021.
- Put way forwards in the quality improvement methodologies and tools of waste management wastes in Berhanena Selam printing enterprise, Addis Ababa, Ethiopia 2021.

1.5 Significance of the study

The printing enterprise can be more productive by minimizing defective products which in turn minimize wastes consumption. The research work can also be used as a source of literature review by other researchers.

Based on the objective of the research, this study would motivate the company to solve the low-quality level problem. The study enhanced the researcher's skills in terms of his research competencies. The experience gained enabled the researcher to carry out other studies of better quality in terms of methodology used and how the results are presented and analyzed.

1.6 Delimitations/Scope of the study

In this study there are three types of delimitations which are geographical, Conceptual, and contextual delimitation presented

Geographically, company has several production sites in Ethiopia, however due to resource and time constraints, the study is limited to focus on only one of the production plant that is Aratkilo main organization. Additionally, focuses only on paper waste generated in offset production and the bindery since the bulk of the paper waste is generated within these departments,

Conceptually, Industrial waste includes all solid, liquid and gaseous waste generated from the production of goods (Shen, 1995). However, as this study is focused on the solid waste generation of paper, the theoretical review has focused on solid waste reductions, and therefore methods of reducing liquid or gaseous wastes will not be thoroughly discussed throughout my research paper.

Contextually, my study focused in identification of the root causes of paper waste activity and minimize by using appropriate quality improvement methodologies and tools.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2. Introduction

This chapter explores relevant literatures and the review was undertaken to bring out the gaps and enhance knowledge for more understanding about waste minimization, quality improvement tools and methods and it applications in printing industry. This chapter has three main sub chapters. The first section focused on overview of waste minimization, definition of waste minimization, classification of waste minimization techniques and Waste Minimization Methodology. The second section deals with **Waste Minimization Audits.** The last subchapter focuses waste minimization and Root Cause Analysis and details explanation of quality improvement tools used in Root Cause Analysis.

2.1 Waste Minimization

2.1.1 Overview of waste minimization

Waste is defined as something lying unproductive, inhabited, or desolate. Generally all waste appears in three forms, namely: solid waste, wastewater (liquid waste), and air emission *(Appiah, 2002).* Waste minimization which is vital to the growth and development of printing houses in Berhanena selam printing enterprise cannot be overemphasized. In order to run a printing house as economically and efficiently as possible, one should reduce all types of wastes including hazardous wastes, solid wastes, and air and water emissions. Waste generation is inevitable in printing industry. When the waste generated causes financial loss to a company and poses a threat to the environment-air, water, and land, then it becomes a problem to society at large.

2.1.2 Definition of waste Minimization

Waste minimization can be defined as "systematically reducing waste at source". It means Prevention and/or reduction of waste generated, Efficient use of raw materials and packaging ,Improving the quality of waste generated to facilitate recycling and/or reduce hazard and Encouraging quality improvement tools Waste minimization is also known by other terms such as *waste reduction, pollution prevention, source reduction and cleaner*

technology.It makes use of managerial and/or technical interventions to make industrial operations inherently pollution free. *(From Waste to Profits, Guidelines for Waste Minimization by National Productivity Council, New Delhi)*

2.1.3 Classification of Waste

It is important to note that waste do differ from process to process and the methods of reducing waste in one printing process do not necessarily apply to other printing processes. There are three major waste streams found in the printing industry. They include: (a) solid waste – in general printing environment solid waste could consist of the following: empty containers, used film packages, outdated materials, damaged plates, developed films, dated materials, test production, bad printing or spoilage, damaged product, and scrap papers (b) water waste – water waste from printing operations may contain lubricating oils, waste ink, clean-up solvents, photographic chemicals, acids, alkaline, and plate coatings, as well as metals such as silver, iron, chromium, copper, and barium and (c) air emissions – printing operations produce volatile organic compound emissions from the use of cleaning solvents and inks, as well as alcohol and other wetting agents used in lithographic printing. Larger plants can be the source of sulfur dioxide emissions (Lewis, 1982). Finishing operations may include final trimming, die cutting, folding, collating, binding, laminating, embossing, and assembling operations. Binding methods include stitching (stapling), gluing, and mechanical binding. The primary waste are binding and laminating chemicals and scrap papers (Banerjee, 2001).

2.1.4 Benefits of waste Minimization

There are several benefits that can be obtained from the implementation of Waste minimization strategies and techniques, including direct economic and environmental benefits *(Crittenden and Kolaczkowski, 1995; EPA, 1988; Franchetti, 2009; Shen, 1995; UNEP/DEPA, 2000)*.Waste represents both energy and material resource losses, and can be an indication of inefficient and unsustainable production processes *(Staniskis and Stasiskiene, 2005).* Waste management efforts can therefore provide direct economic benefits, as reducing the amount of waste produced commonly coincides with increased efficiency, productivity and profitability *(Weinrach, 2001).* Cost savings are derived from

the avoidance of waste hauling and handling activities, less purchased material, and revenues obtained from the sale of recyclables *(Franchetti, 2009; Visvanathan, 2007; EPA, 1992; UNEP, 1991).*

Waste minimizations also provides several environmental benefits as it decreases the need to harvest new material, saves energy, reduces greenhouse gas emissions and waste quantities that needs to be recycled, recovered or disposed *(EPA, 2015b).* Furthermore, recycling practices also result in less waste in landfills and the conservation of energy and natural resources *(Franchetti, 2009; Tchobanoglous and Kreith, 2002).* Waste management efforts can also assist in the achievement and improvement of regulatory requirements and therefore reduce the regulatory burden and risk of receiving fines *(Crittenden and Kolaczkowski, 1995; Cheremisinoff, 2003; EPA, 1992), thereby reducing environmental liability risks (EPA, 1988; Franchetti, 2009; Shen, 1995; UNEP/DEPA, 2000).*

Besides economic, environmental and liability risk benefits, personal and social benefits of stakeholder can be obtained *(Franchetti, 2009; UNEP/DEPA, 2000).* The well being of employees can increase as cleaner facilities often results from reduction activities, moreover helping the environment can provide personal satisfaction for stakeholder *(Franchetti, 2009).* Furthermore, the application of sustainable practices can improve corporate image and attract new environmentally conscious customers, employees and partners who share the same values *(Franchetti, 2009).*

2.1.5 Barriers to waste Minimization efforts

The main potential barriers that can hinder the implementation of waste reduction activities and efforts are economic, regulatory, technical and cultural aspects *(Crittenden and Kolaczkowski, 1995).* Waste reduction efforts often provide benefits in the long-term, and as environmental activities seldom have clear-cut budgets set aside, competing for funding with other projects that provide short-term benefits presents an obstacle (*Sharma, 2001*). If larger monetary investments are needed, the less tangible benefits of reduction efforts should be included when assessing economical feasibility, such as allocating waste disposal and handling costs to specific operations *(Crittenden and Kolaczkowski, 1995).* Regulatory barriers might seem unlikely as waste minimization efforts should

decrease the environmental burden, but undertaking process changes may involve alterations to licenses or other regulatory approvals *(Crittenden and Kolaczkowski, 1995)*. However, since one of the main goals of waste management initiatives is to benefit the environment, these barriers are often relatively easy to overcome by working with regulatory bodies during planning processes *(Crittenden and Kolaczkowski, 1995)*.

A lack of sufficient process and engineering knowledge of production techniques are great technical obstacles to successful waste reduction implementations and efforts (*Crittenden and Kolaczkowski, 1995; Visvanathan, 2007*). Inevitably there are risks involved when changes are made to industrial processes, thus it is common that concerns regarding the risk of affecting the quality of the product and/or customer acceptance arises (*Crittenden and Kolaczkowski, 1995)*. Production personnel and other stakeholders can therefore easily turn down new procedures due the risks associated with process changes if the improvement facilitator lacks sufficient knowledge of the process (*Sharma, 2001*). Furthermore, as production stoppages and new bottlenecks can arise, process changes should always be pilot tested and the feasibility and efficiency of changes assessed *(Crittenden and Kolaczkowski, 1995)*.

The greatest challenges when implementing waste reduction techniques are however often cultural and connected to organizational resistance *(Sharma, 2001). In a study performed by the AEBN (2003),* it was concluded that reduction improvements and process efficiency requires management change, as resistance to change was identified as the main obstacle for improving waste management practices within printing companies. Attitudinal changes in directors, managers and employees are often crucial in order to obtain the most from reduction methodologies *(UNEP/DEPA, 2000).* Resistance to change can arise for several different reasons such as lack of senior management commitment, insufficient awareness of corporate goals and objectives, poor internal communication, inadequate training, inflexible organiza□ tional structures and bureaucracy (*Crittenden and Kolaczkowski, 1995*). Moreover, as people disconnected from the production floor often set environmental programs or strategies, and employees connected to production mostly focus on keeping the manufacturing line up and running, making process changes to benefit the environment are often neglected (*Sharma, 2001*).

2.2 Waste Minimization Audits

A waste Minimization audit is a methodology that helps to identify areas of inefficient resource consumptions and poor management of waste within an organization (UNEP/DEPA, 2000), and provides a solid foundation for a practical and successful implementation of a waste reduction program (Khor et al., 2007). Understanding how, why and where wastes are generated in the production process is a prerequisite for effectively preventing or reducing industrial wastes (UNEP, 1991). Knowing where wastes originate and problems arise in the process enables areas to be identified where waste reduction and cost saving is possible (UNEP, 1991). Therefore, an integral part of many waste reduction programs or strategies is to perform a Waste Minimization Opportunity Assessment (WMOA), also referred to as a Pollution Prevention Opportunity Assessment, Cleaner Production Assessment, solid waste assessment, waste-minimization audit or green audit (EPA, 1988; UNEP, 1991; Van Berkel, 1994; Mulholland and Dyer, 2001; Sharma, 2001; Franchetti, 2009; Visvanathan, 2007).

A WMOA is a systematic framework used to identify waste minimization opportunities, and is often presented as a structured step-by-step program with intermediate milestones (Sharma, 2001) and can be a starting point for investigating pollution issues at any facility (Avşar and Demirer, 2008). A WMOA generates a comprehensive understanding of a facility's processes and wastes, identifies waste reduction opportunities and evaluates the feasibility of their implementation (Sharma, 2001). The rationale behind WMOA procedures is that accurate information about the origins and sources of waste is a prerequisite for effective waste reduction (UNEP, 1991). Once the sources are identified the most effective options for avoiding and reducing wastes can be identified (UNEP, 1991). The WMOA procedure involves measuring, observing and recording data, and incorporates collecting and analyzing waste samples (UNEP, 1991). The assessment procedure can be performed on different levels depending on its purpose; on a regional level it can point out problematic industries; on plant level wastes can be tied to specific processes; and on process level, root causes and exact origins of wastes can be identified (UNEP, 1991). Over the years, a number of generic qualitative frameworks describing how to conduct a WMOA have been developed. Authors include the United States

Environmental Protection Agency (EPA, 1988; EPA, 1992), the United Nations Environment Programme (UNEP, 1991), Khor et. al (2007), Visvanathan (2007), and Franchetti (2009). The frameworks present similar qualitative evaluation programs aimed at identifying waste minimization opportunities at industrial scale (Musee et al., 2007), and share key charcteristics.

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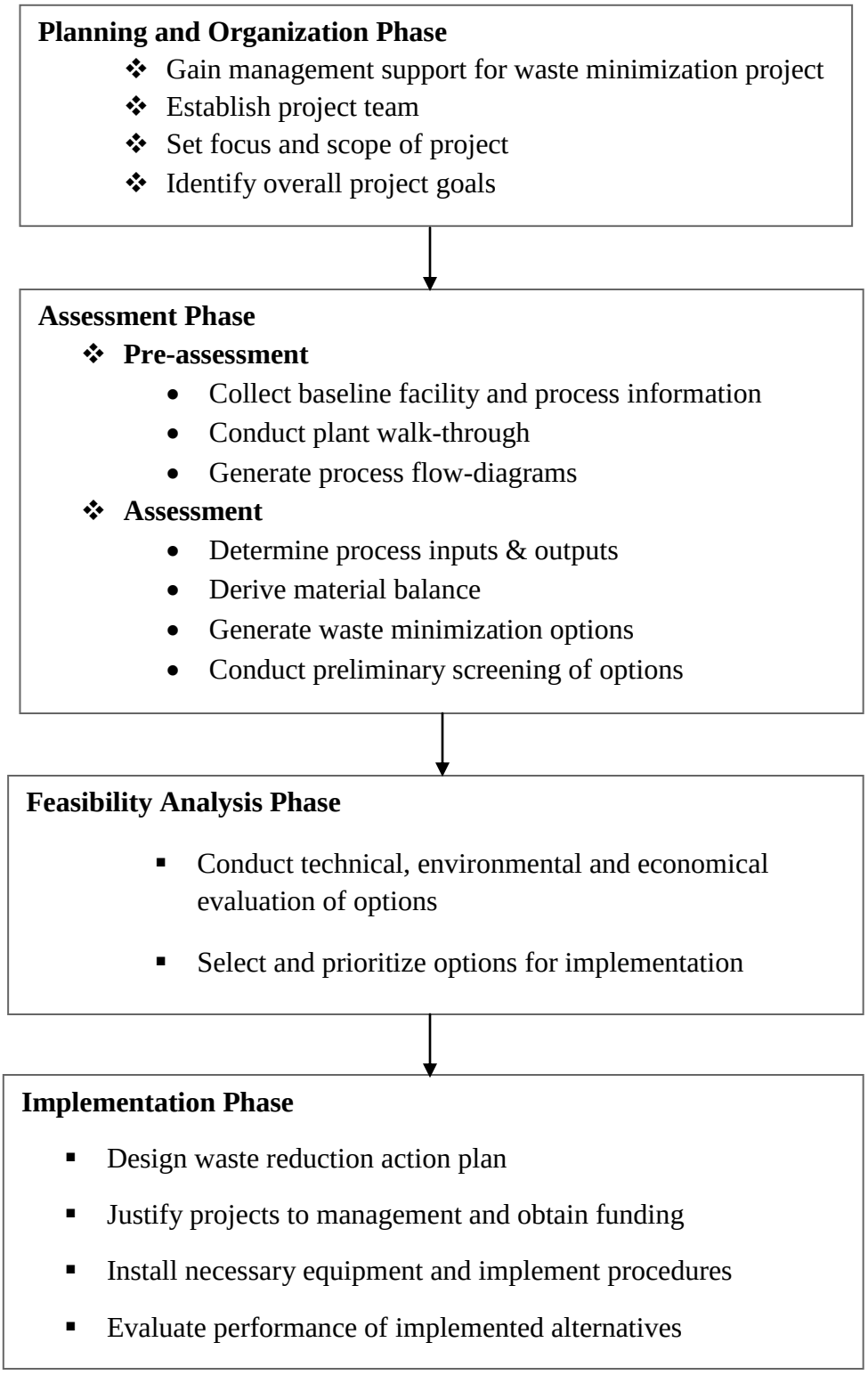

Figure 1 Generic steps of a WMOA framework. Adapted from EPA (1988), UNEP (1991), Visvanathan (2007) and Franchetti (2009)

2.2.1 Planning and organization

The first step of a WMOA is to thoroughly prepare the organization for the audit exercise so that it is carried out within budget and time, and with as little interference to normal plant activities as possible (Visvanathan, 2007). Main undertakings in this phase include forming a project team, gaining management support and commitment and defining scope and goals of the audit (EPA, 1988; UNEP, 1991). A prerequisite for a successful WMOA is that top management shows support for the project and that employees are involved and made aware of the initiative (Visvanathan, 2007). Top management should establish a formal commitment throughout the organization, and waste minimization should be communicated to be an important focus of the company (EPA, 1988). This can be done by releasing a formal policy statement or a memo that highlights the importance of the new waste minimization initiative and encourages staff to take part and contribute (Franchetti, 2009). Using bonuses, prizes and other forms of recognition are common ways to raise motivation and participation among employees (EPA, 1988). Using posters to inform about the pollution scenario at the company, and about the benefits, objectives and goals of the waste minimization initiative can also help boost staff interest and involvement (Visvanathan, 2007).

Another key element in the preparatory work for a waste audit is forming a team responsible for all subsequent WMOA work (Visvanathan, 2007). The team can range from a few people with contributions from employees in a small factory, to many people including environmental specialists, production employees and technical staff, all depending on size and complexity of the process that will be studied (UNEP, 1991). The EPA (1988) suggests that at least two people should be involved in the team to obtain a variety of perspectives and viewpoints. For the team to have a higher degree of authority in the organization and swifter communication with management, the team leader should be in a managing position (Franchetti, 2009).

Before undertaking the actual auditing process the scope and focus of the audit needs to be established (Franchetti, 2009). The scope and focus depend on the main objectives and goals of the waste audit (UNEP, 1991). If the scope is not aligned with the goals of the waste minimization project, audit efforts may go to waste (Visvanathan, 2007). The purpose of having project goals and objectives is to provide specific direction for the

audit and they should therefore be measurable, realistic and achievable (Visvanathan, 2007). Also, if the project objectives are not clear and precise enough, there is a risk that they merely become vague and generalized improvement slogans, unable to provide the direction needed (Franchetti, 2009).

Audit objectives often stem from determining the major problems and wastes associated with the specific production process (UNEP, 1991). Objectives may for example include minimizing raw material losses and reducing wastes for which disposal costs are high or for which regulations exist (UNEP, 1991). Other common waste audit objectives are to reduce toxic and hazardous wastes and to improve operational health and safety (Visvanathan, 2007). An audit can have the objective to look at waste minimization as a whole and therefore focus on a complete production process, or in other cases the main concern might be a specific waste stream, motivating a more narrow focus on specific unit operations (UNEP, 1991). The audit frameworks provide general guidelines for identifying waste reduction opportunities and should therefore be altered to fit the specific needs of a company or situation (UNEP, 1991).

2.2.2 Assessment

The purpose of the assessment phase is to get a detailed understanding of facility operations and waste streams, and to identify and screen waste minimization options (EPA, 1988). Generating such a comprehensive understanding requires the collection and compiling of baseline information from a wide variety of sources, sometimes ranging over the entire cross-section of the facility (Visvanathan, 2007). A commonly suggested first step in this phase is therefore to review existing process and facility data such as process flow diagrams, operating manuals, raw material invoices, purchasing and inventory logs, and recycling records (UNEP, 1991; EPA, 1988). Examining existing organizational records regarding processes, operations and waste management practices provides the team with important background information, helps them determine areas of interest and may reveal opportunities to minimize wastes (EPA, 1988). Useful sources of information for this step are organizational data, material and product data, raw material and logistic consumption data, process data, environmental data, management data, financial data and industry data (Visvanathan, 2007).

Facility Walk Through

An important part of generating baseline information is to conduct a thorough walkthrough of the entire manufacturing plant so that a true picture of all processing operations and their interrelationships can be had (UNEP, 1991). The walkthrough should follow the material flow through the facility, from storage of raw material to the storage of final products, without skipping any process step (Visvanathan, 2007). During the plant tour, team members should examine all production activities, and key figures and facts so that nothing is overlooked, as even trivial observations may be useful at a later stage (Visvanathan, 2007). This includes taking detailed notes of observations and discussions; sketching process layouts, material flows and site plans; and consulting plant employees about normal operating conditions (UNEP, 1991). Conversations with production staff may reveal important information regarding actual operating procedures, waste discharge points, unplanned wastes such as spills, and process problems (UNEP, 1991).

Constructing Process Flow Diagrams

A crucial step in gaining detailed insight into the production processes is constructing process flow diagrams, through which important process steps are visualized, and sources of waste generation identified (Franchetti, 2009; UNEP, 1991; Visvanathan, 2007; EPA, 1988). The purpose of the process flow diagram is to help the audit team fully comprehend the business processes and capabilities of the production site so that well-grounded alternatives to minimize waste may be developed (Franchetti, 2009). A process flow diagram visually represents the workflow of a process or an entire operation, and is made up of a set of activities that transform well-defined inputs to outputs (Franchetti, 2009). The diagram should be founded on baseline data collected through a plant tour and existing records review, and should contain information from the unit operations relevant to the project (Visvanathan, 2007). The detail level required to achieve the project objectives is important to consider when constructing a process flow diagram (UNEP, 1991). The less detailed or the larger the audit becomes, crucial information tends to become oversimplified or be lacking altogether in the process flow diagram, undermining its purpose (UNEP, 1991).

Generating a material balance

Next a detailed account of inputs and outputs for target processes should be determined so that waste streams, their composition, and previously unknown material losses can be quantified (Franchetti, 2009; EPA, 1988; UNEP, 1991; Visvanathan, 2007). Proposed methods to achieve abovementioned goals include generating a material balance (EPA, 1988; UNEP, 1991; Visvanathan, 2007) or conducting a facility waste sort (Franchetti, 2009). Both methods entail similar data collection methods and share the ultimate goal of generating a base of information from which waste minimization options can be identified (Franchetti, 2009; UNEP, 1991; Visvanathan, 2007; EPA, 1988).

Generating a material balance to characterize waste streams can require great effort but often results in a more detailed picture of the waste situation (EPA, 1988), and highlights areas of concern where e.g. information is inaccurate or lacking (Visvanathan, 2007). Moreover, a material balance helps focus waste minimization activities and provides a baseline for measuring performance (EPA, 1988).

Generating a material balance starts by determining and quantifying inputs such as raw materials, chemicals, air and water to the processes and each unit operation (UNEP, 1991). A first step in doing so is to study raw material purchasing rec□ ords and to examine storage and material handling operations. This to get an understanding of the net input to the process as raw material losses often arise from storage and handling practices (UNEP, 1991). Raw material consumption rates of the relevant unit operations should also be determined, which may require taking measurements and making observations in production and deriving average consumption figures (UNEP, 1991).

The second half of a material balance entails quantifying process outputs. Outputs include products and by-products, as well as solid and liquid wastes, including those which may need to be transported off-site for treatment and disposal (Visvanathan, 2007). Quantifying outputs often entails reviewing company records of products and wastes sent off-site, and measuring production rates over a period of time (UNEP, 1991).

The material balance is generated by comparing input figures with output figures. Ideally they should equal each other, but this is rarely the case in practice (Visvanathan, 2007). Arriving at an accurate material balance requires refining collected data and being aware of factors that could over- or underestimate waste streams (Visvanathan, 2007). A

significant material imbalance can point to potential material losses or waste discharges, but can also be a result of measurement errors or overlooked material flows (UNEP, 1991). To obtain a satisfactory material balance some data collection activities may need to be repeated, and unit operations re-examined (UNEP, 1991). Reviewing and complementing collected data may be crucial in obtaining an accurate and comprehensive picture of the material flows, which is a prerequisite for a successful waste audit and waste reduction action plan (UNEP, 1991).

Identify Waste Minimization Options

The material balance helps describe the nature of wastes and material flows in the production process, and can help identify areas of concern, sources of wastes and areas of unexplained losses (UNEP, 1991). With the information from the material balance and site inspection as foundation, possible ways to minimize waste in the assessed area can be identified (Visvanathan, 2007). An effective way to generate waste minimization alternatives is to use brainstorming or other group decision techniques in an environment which encourages creativity and independent thinking (EPA, 1988). Discussing with plant engineers and operators, equipment manufacturers, trade associations, and environmental consultants, as well as benchmarking and using literature may also provide the team with valuable input for creating alternatives (Franchetti, 2009). The process of conceiving waste minimization alternatives should follow the waste management hierarchy discussed in chapter 2.1 so that options preventing waste generation are explored first (EPA, 1988).

Waste minimization options can be divided into two categories depending on their requirements in terms of effort, time and financial resources: obvious measures, and long-term measures (Visvanathan, 2007). Obvious waste-reduction measures are cheap and quick to implement and require little effort. They are simple adjustments that may increase efficiency, and often target unnecessary material losses (UNEP, 1991). These obvious options can include improved management techniques and tightening up housekeeping procedures (Visvanathan, 2007) such as those for ordering, receiving, handling and storing materials (UNEP, 1991). However, certain waste problems may require more than simple procedural changes and improved housekeeping practices to solve. In these cases implementing longterm reduction options involving significant

modifications to, for example, production processes, equipment, technology, and raw material types may be necessary (UNEP, 1991).

Screening Waste Minimization Alternatives

In a successful WMOA many waste minimization alternatives will be identified (EPA, 1988). Evaluating the economical and technical feasibility of all alternatives would be very costly and time consuming, which is why a quick screening procedure is put in place to identify options with the highest potential to minimize waste and reduce costs (Franchetti, 2009). Screening procedures can range from an informal evaluation where the assessment team selects the best alternatives based on group discussions, to more formal quantitative methods such as the weighted sum method (EPA, 1988) and the House of Quality (Franchetti, 2009). An informal evaluation works best when only a few minimization options have been generated, and quantitative methods are recommended when a large number of alternatives exist (EPA, 1988). To be effective, a screening procedure should consider the main implications of each generated option, including the expected reduction of waste and raw material consumption, cost and ease of implementation, and impact on employee moral (Franchetti, 2009). The result from the screening procedure indicates which options are suitable for a more thorough feasibility analysis (EPA, 1988).

2.2.3 Feasibility Analysis

When waste reduction opportunities have been screened and prioritized the remaining alternatives need to be further evaluated and ranked based on their economical and environmental impact, and technological feasibility (EPA, 1988). In this step it is important to consider the main objectives and goals of the project, and to which extent the waste minimization options will fulfill them (Franchetti, 2009). Evaluating some options may require substantial analysis and may include reaching out to vendors for additional equipment information or analyzing market trends for recyclable commodities (Franchetti, 2009). The advantages of other waste minimization options may be more obvious and require little analysis to identify, in which case they can be ready for implementation without rigorous evaluation efforts (EPA, 1988). Such options can for example be procedural and housekeeping changes that require small investments and can

be implemented quickly (EPA, 1992). secure the gains should be taken (Bergman and Klefsjö, 2010). Improvements needs to be consolidated through for example standardization i.e. introduction of new standard procedures (Bergman and Klefsjö, 2010). Another part of the implementation phase is to get support for the implementation from top management and to secure funding for the suggested alternatives. This may require necessary project investments to be comprehensively justified, and additional data to be gathered and presented in order to convince key decision-makers (EPA, 1992). It is recommended that the reduction options be implemented slowly and consistently in stages so that employees have time to adjust to the changes (UNEP, 1991), and the impact on production processes and finances can be kept low (Visvanathan, 2007).

By comparing the initial goals of the implemented options to their actual performance, an evaluation of their effectiveness can be made (EPA, 1988). If goals are not met or performances are worse than expected, the options may require modifications or rework (Franchetti, 2007). To keep employees motivated and involved in the changes, training program and reward systems can be put in place (UNEP, 1991). Ensuring that information about upcoming changes and their underlying reasons has been clearly communicated may also reduce workforce resistance and increase their buy-in to the projects (Franchetti, 2007).

2.3 Waste minimization and Root causes analysis

2.3.1 Introduction to Root Cause Analysis (RCA)

Wilson et al. (1993) have defined the Root Cause Analysis as an analytic tool that can be used to perform a comprehensive, system-based review of critical incidents. It includes the identification of the root and contributory factors, determination of risk reduction strategies, and development of action plans along with measurement strategies to evaluate the effectiveness of the plans.

Canadian Root Cause Analysis Framework (2005) says that root cause analysis is an important component of a thorough understanding of "what happened". The team begins by reviewing an "initial understanding" of the event and identifying unanswered questions and information gaps. The information-gathering process includes interviews with staff, who were directly and indirectly involved, examination of the physical

environment where the event and other relevant processes took place, and observation of usual work processes. This information is synthesized into a "final understanding", which is then used by the team to begin the "why" portion of the analysis.

Similarly, to solve a problem, one must first recognize and understand what is causing the problem. This is the essence of root cause analysis. According to Wilson et al. (1993) a root cause is the most basic reason for an undesirable condition or problem. If the real cause of the problem is not identified, then one is merely addressing the symptoms and the problem will continue to exist.

Dew (1991) and Sproull (2001) state that identifying and eliminating root causes of any problem is of utmost importance. Root cause analysis is the process of

identifying causal factors using a structured approach with techniques designed to provide a focus for identifying and resolving problems. Tools that assist groups and individuals in identifying the root causes of problems are known as root cause analysis tools.

According to Duggett (2004) several root cause analysis tools have emerged from the literature as generic standards for identifying root causes. Some of them are the Why Why Analysis, Multi Vari Analysis, Cause-and-Effect Diagram (CED), the Interrelationship Diagram (ID), and the Current Reality Tree (CRT). He has added that Why Why analysis is the most simplistic root cause analysis tool where as current reality tree is used for possible failures of a system and it is commonly used in the design stages of a project and works well to identify causal relationships. There is no shortage of information available about these tools.

The literatures confirmed that these tools do, in fact, have the capacity to find the root causes with varying degrees of accuracy, efficiency, and quality. DOE Guideline Root Cause Analysis Guidance Document February (1992) says that immediately after the occurrence identification, it is important to begin the data collection phase of the root cause process using these tools to ensure that data are not lost. The data should be collected even during an occurrence without compromising with safety or recovery. The information that should be collected consists of conditions before, during, and after the occurrence; personnel involvement (including actions taken); environmental factors; and other information having relevance to the condition or problem. For serious

cases,photographing the area of the occurrence from several views may be useful in analysis. Every effort should be made to preserve physical evidence such as failed components, ruptured gaskets, burned leads, blown fuses, spilled fluids, and partially completed work orders and procedures. This should be done despite operational pressures to restore equipment to service. Occurrence participants and other knowledgeable individuals should be identified.

Anderson and Fagerhaug (2000) have simplified the root cause analysis. They provide a comprehensive study about the theory and application of metrics in root cause analysis. It emphasizes the difficulty in achieving process capability in software domain and is cautious about SPC implementation. They mention that the use of control charts can be helpful for an organization especially as a supplementary tool to quality engineering models such as defect models and reliability models. However, it is not possible to provide control as in manufacturing since the parameters being charted are usually in-process measures instead of representing the final product quality. The final product quality can only be measured at the end of a project as opposed to the production in manufacturing industry, so that on-time control on processes becomes impossible. They also underline the necessity of maturity for achieving process stability in development of product quality and productivity. Finally, they bring a relaxed understanding by stating that the processes can be regarded in control when the project meet inprocess targets and achieves end-product quality and productivity improvement goals.

Arcaro (1997) has presented various tools for identifying root causes. He describes that RCA techniques are constrained within domain and give a detailed tutorial by supporting theoretical knowledge with practical experiences. He states that all RCA techniques may not be applicable for all processes. Brown (1994) has used the root cause technique to analyze the assembly of commercial aircraft. He has concluded that it is the most effective tool to eliminate the causes in most vital assemblies like aircraft, where utmost safety and reliability is needed.

Brassard (1996), and Brassard and Ritter (1994) have put their emphasis on continuous improvement and effective planning. They have pointed out that Root Cause analyzing tools give management to think ahead about failures and plan accordingly. They

emphasize that process improvement models implicitly direct companies to implement RCA as a crucial step for project level process control and organizational level process improvement purposes. Quantitative Process Management requires establishing goals for the performance of the project's defined process, taking measurements of the process performance, analyzing these measurements, and making adjustments to maintain process performance within acceptable limits. Cox and Spencer (1998) have advocated that RCA tools effectively give solution to handle constraints and arrive at an appropriate decision.

Like Cox and Spencer (1998), Dettmer (1997) has also used root cause analysis on management of constraints. He presents one of the earliest studies on the debate of applying Root Cause Analysis to processes. A proper management decision is necessary to succeed the RCA tools and methods in a particular environment. Lepore and Cohen (1999), Moran et al. (1990), Robson (1993) and Scheinkopf (1999) move ahead that when change is needed, then think root cause analyzing, identifying and eliminating. The foundations of their studies are pioneering one as they question an accepted practice for root cause analysis and the results of the example studies are encouraging. However, the studies are far from being practical one as they include too many parameters and assumptions.

Smith (2000) has explained that Root Cause Tools can resolve conflicting strategies, policies, and measures. The perception is that one tool is as good as another tool. While the literature was quite complete on each tool as a stand-alone. application and their relationship with other problem solving methods. There are very few literatures available on the comparative study of various root cause analysis tools and methods. The study on three tools namely Cause-and-Effect Diagram (CED), the Interrelationship Diagram (ID), and the Current Reality Tree (CRT) is deficient on how these three tools directly compare to each other. In fact, there are only two studies that compared them and the comparisons were qualitative. Likewise, Fredendall et al. (2002) have also compared the CED and the CRT using previously published examples of their separate effectiveness. While Pasquarella et al. (1997) compared CED, ID and CRT on Equipment/Material Problem, Procedure Problem, Personnel Error, Design Problem, Training Deficiency, Management

Problem and External Phenomena using a one-group post-test design with qualitative responses.

There is little published research that quantitatively measures and compares the Why Why Analysis, Multi Vari Analysis, Cause-and-Effect Diagram (CED), the Interrelationship Diagram (ID), and the Current Reality Tree (CRT). Geno (2007) has presented some insight into the comparison of common root cause analysis tools and methods. He indicates that there are some comparative differences between tool and method of a RCA. He has added that tools are included along with methods because tools are often touted and used as a full blown root cause analysis.

2.3.2 Root cause analysis tools and techniques

Many Root Cause Analysis Tools have emerged from the literature as generic standards for identifying root causes. They are the Cause-and-Effect Diagram (CED), the Interrelationship Diagram (ID), and the Current Reality Tree (CRT), Why Analysis, Pareto diagrams, and Multi vari analysis. Sample of information is available about these tools, in open literature (See References).

2.3.2.1 Causes-and-effect diagram (CED)

This diagram, also called Ishikawa or Fishbone Diagram, is used to associate multiple possible causes with a single effect. The diagram is constructed to identify and organize the possible causes for a particular single effect. Causes in Cause and Effect Diagram are frequently arranged in four major categories. For manufacturing cases it is Manpower, Methods, Materials and Machinery. For Administration and service sectors, it is Equipment, Policies, Procedures and People. Ishikawa advocated the CED as a tool for breaking down potential causes into more detailed categories so that they can be organized and related into factors which help in identifying the root cause

2.3.2.2 Interrelationship diagram (ID)

Mizuno supported the ID as a tool to quantify the relationships between factors and thereby classify potential causal issues or drivers. The interrelationships among the operations are shown as 'in and out' in each stages of operation. The weight factors, which may include causes, effects, or both, of in and out are determined on the basis on logical sequence.

2.3.2.3 Current reality tree (CRT)

Current Reality Tree is a tool to find logical interdependent chains of relationships between undesirable effects leading to the identification of the core cause. It depicts the real status under prevailing current conditions with regard to causality, factor relationships, usability, and participation.

2.3.2.4 Why analysis

An important component of root cause analysis is a thorough understanding of "what happened". The team begins by reviewing an "initial understanding" of the event and identifying unanswered questions and information gaps. The information-gathering process includes interviews with staffs and workers who were directly and indirectly involved with the physical environment where the event and other relevant processes took place, along with observation of usual work processes. This information is synthesized into a "final understanding", which is further used by the team to begin the "why" portion of the analysis in a logical sequence to find a logical solution to the problem.

It is one of the many brainstorming methodology of asking "why" five times repeatedly to help in identifying the root cause of a problem. If a problem is repeatedly questioned, each time an alternative solution comes out which is linked to the root cause. However, asking why may be continued till getting an agreeable solution. Five is an arbitrary figure. The theory is that after asking "why" five times one is likely to arrive at the root cause.

2.3.2.5 Pareto Diagram

Pareto Diagram is a tool that arranges items in the order of the magnitude of their contribution, thereby identifying a few items exerting maximum influence. This tool is

used in SPC and quality improvement for prioritizing projects for improvement, prioritizing setting up of corrective action teams to solve problems, identifying products on which most complaints are received, identifying the nature of complaints occurring most often, identifying most frequent causes for rejections or for other similar purposes. The origin of the tool lies in the observation by an Italian economist Vilfredo Pareto that a large portion of wealth was in the hands of a few people. He observed that such distribution pattern was common in most fields. Pareto principle also known as the 80/20 rule is used in the field of materials management for ABC analysis. 20% of the items purchased by a company account for 80% of the value. These constitute the A items on which maximum attention are paid. Dr. Juran suggested the use of this principle to quality control for separating the "vital few" problems from the "trivial many" now called the "useful many".

Multi vari analysis

It is the tool of finding root causes and its relationship with Cyclic Error, Temporal Error and Positional Error. Its aim is to find out whether a cause is repeatable in nature or not. If it is repeated, it has reoccurred at the certain intervals or not. The causes have re-occurred or not in a particular position. In fact the basic intent of this tool is to find out why this variation has taken place from the specified specifications. The main objective of a Multi Vari Analysis is to reduce a large number of unknowns and unmanageable causes of variation to a much smaller family of related variables containing the dominant cause. The basic data required for Multi Vari Analysis are the following:

- Number of day’s sample data is taken
- Number of shifts per day
- Number of hours in a shift that sample data is taken
- Number of units in an hour that sample data is taken from

Factors, which may include causes, effects, or both and their levels

CHAPTER THREE

RESEACH DESIGN AND METHODS

3.1. The study Area profile

The study was conducted at Berhanena selam printing enterprise which is located in Addis Ababa. And it was established with the consent of Leul Ras Teferi in December 1924 in Addis Ababa. When it started printing of the first newspaper called 'Berhanena Selam (Light and peace), the name 'Berhanena Selam ‘for the present printing press was adopted from this newspaper. *(BSPE profile).*

3.2. Source and Study of population

Our general population were all printing enterprise in Addis Ababa. Our source populations were all peoples found in Berhanena selam printing enterprise and our study populations were peoples found in printing department of Berhanena selam printing enterprise.

3.3. Data Collection Instrument and Technique

Both primary and secondary data were collected from the study area using structured questioner which is developed from referring and reviewing different literatures related to our objective (Jastin H lal 2020). Primary data were collected by interviewing the all peoples work in the study area by filling the questioner. The secondary data were collected by reviewing existing archives (data base) and direct observation of the activities in the printing rooms

3.4. Research Methods and Design

In this study both qualitative and quantitative methods of data collection were used. Case study design with cross sectional time dimension was applied to assess types of wastes and roots causes of the wastes in Berhanena selam printing enterprise.

3.5. Sample Size determination and sampling technique

Berhanena printing enterprise was selected using convenience sampling technique which is was based on time and resource we have. There was no sampling technique for study

Participants since all were included. In the study all population (N=32) work in Berhanena printing enterprise Aratkilo main office specifically at printing department were included.

3.6. Data analysis Methods

The questioner were distributed and collected by principal investigator and all questioner were filled. A total of 32 peoples work in the printing department were interviewed and the secondary date were collected using observation to fill according to the questions in the questioner. After the data collected and checked for its cleanness the quantitative data were entered and analysis were done using Excel work sheet version 2013. Descriptive analysis (frequency and percentage) were done was done using pivot table analysis. To identify the main type of wastes pareto chart way of analysis were used and for root cause analysis fish bone diagram were used. After the data analysis data were presented using narration, table and figure.

3.8. Ethical considerations

The researcher obtained an authorization letter from the University (smu) and Berhanena ena Selam printing enterprise. The target respondents were fully informed about the purpose, method, and intended possible uses of the research, what their participation in the research entails and what risks than informed consent were given for study participants. The confidentiality of information supplied and the anonymity of respondents were respected.

3.9. Research Frame work

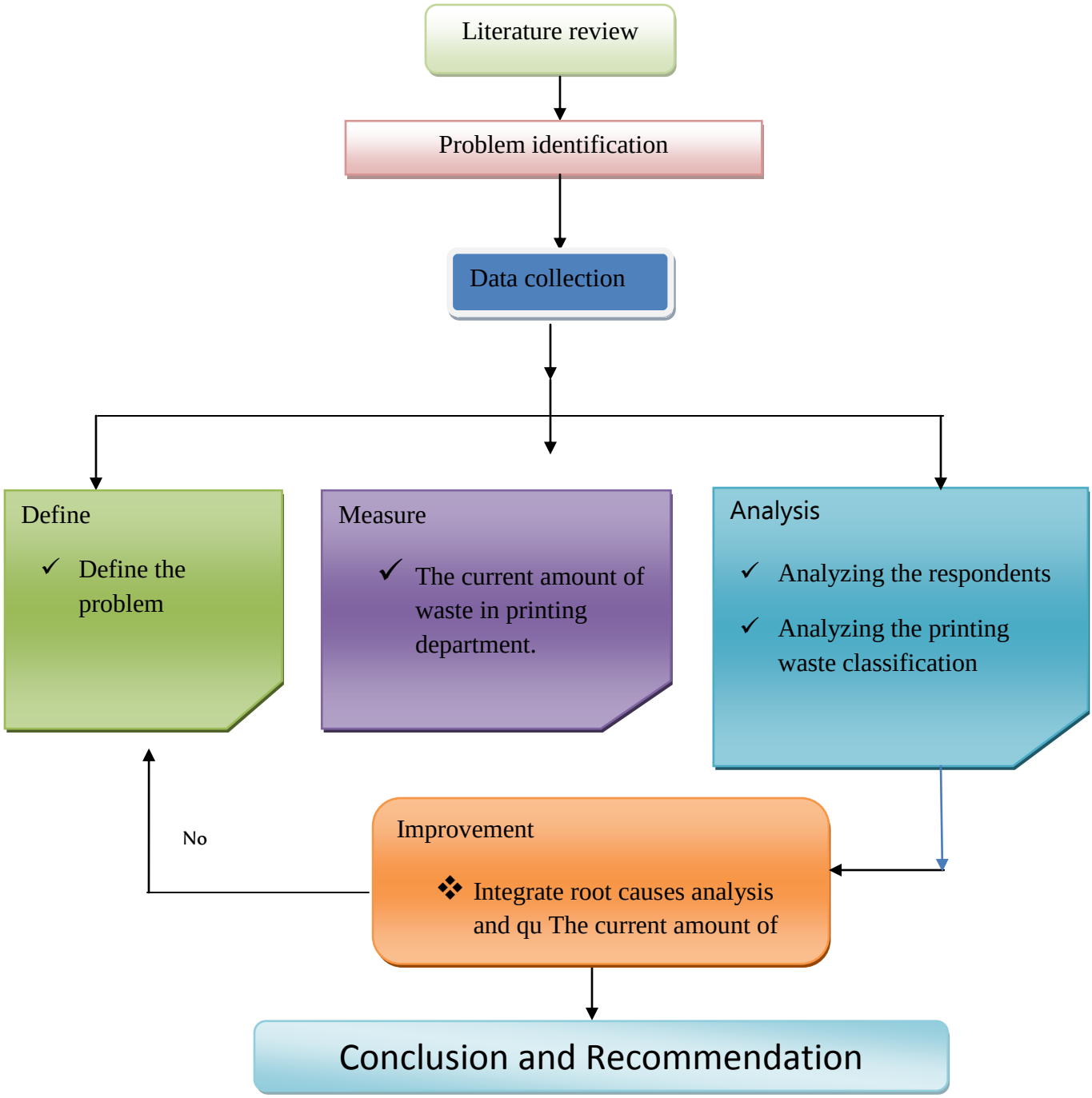

Figure 2. Research Framework

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

In this chapter, the collected data was presented, analyzed and interpreted in light of the research objectives. A descriptive technique of data analysis was employed in the company. This chapter consists of a qualitative and quantitative analysis having five major sections, which answered the research questions raised in chapter one.

4.2. Socio-Demographic Characteristics

In this research study the total population is 31 among them majority of the respondents who works in the printing department were male (70.97%) and their age range were from 21- 30 years (41.93%). About 48.9% of the respondents were under 12 grades and the majority of them works less than five year in the department (48.38%).

Study variables		Frequency	Percentage
Sex	Male	22	**70.97**
	Female	9	29.03
Age	< 20 years	5	16.12
	21-30 years	13	**41.93**
	31-45 years	10	32.25
	above 45	3	9.677
Educational status	< 12 grade	15	**48.4**
	Deploma	13	**41.93**
	Degree	2	6.45
	Masters	1	3.22
Service year	0-5 years	15	**48.38**
	6- 10 years	9	29.03
	> 11 years	7	22.59
Have you try to minimize wastes	Yes	20	64.5
	No	11	35.5

Table 1. Socio-Demographic

4.3. Identification of the Current Existing Wastes in the Company

Under this section the research study starts by explaining how newspaper is making in the company? This is helpful for identifying the current existing wastes in the company. So that the News-print is the printing paper which is used to produce a newspaper. The paper is supplied by the paper-making factory in the form of reels. These reels have different specifications such as different sizes, color, pulp quality etc. After manufacturing, the reels are loaded in containers and delivered through ships by the paper-making factory then; the containers are off-loaded at destination seaports, brought to warehouse via trains, stored, before being ultimately delivered to the printing sites with the help of trucks and forklifts. Other than the news-print several materials such as ink, plates, chemicals, electricity, water etc. are required in the production of a newspaper.

When we come to the main point during the process of producing newspaper and also before starting the process there are certain wastages occurring specially in the printing department as shown in the figure below.

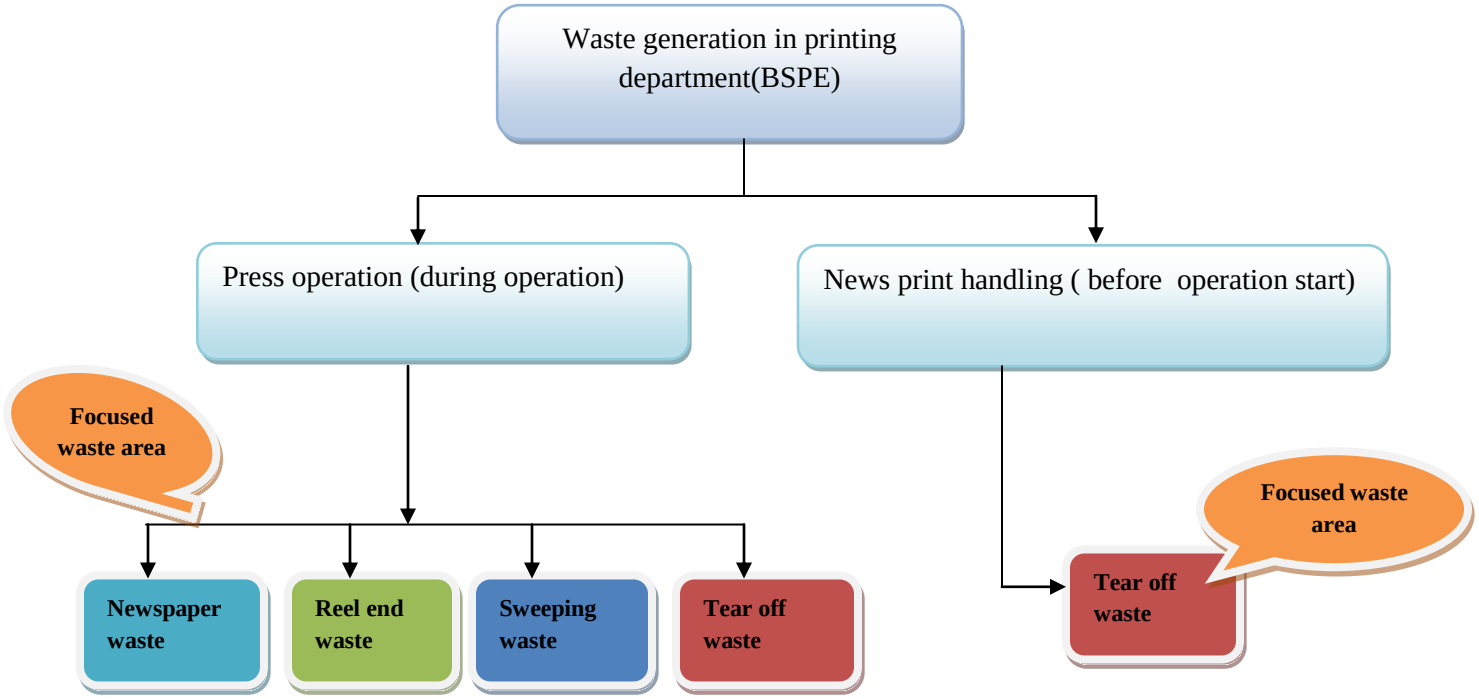

Figure 3: Waste generation in printing department

The above diagram shows that there two main categories of waste generation in printing department i.e. press operation and news print handling. Under press operation there are four major wastes is illustrated such as Newspaper waste, Reel-end waste, sweep waste, and Tear-off waste. Under News print handling there is tear-off waste this waste mainly occurred due to improper transit and forklift operation.

4.4. Definitions on Focused Area of Wastes Based on the Current Activities of a Company

1) TEAR-OFF WASTE: this kind of waste mostly occurred in the company where A newsprint reel brought to the shop floor is loaded on the reel stand of the press where the wrapper is removed. The top most layers which are damaged due to transit are sliced off.

2) **SWEEP- WASTE :** during the process of Newspaper making the paper is then threaded through the press due to which some amount of it is wasted.

3) NEWS-PAPER WASTE: the final products of a news-paper (copies) get wasted because of not fulfill the order or specifications for example color blurred and imperfect dimension.

4) REEL- END WASTE: The butt end of the newsprint reel that is left behind after splice

4.5. Data Collection on Focused area Wastes for One Month (kilogram per week)

During survey for four consecutive weeks from the printing department experts the research study get quantifiable data measured in kilogram(kg) on the wastes observed during the production process that are described in the table below. The reason for collecting this quantifiable data is in order to gain the most contributing factor waste that helps for next work such as drawing Pareto Diagram followed by Root cause analysis.

Focused area of wastes	1st week(April 2021) Kg/week	2nd week (April 2021) Kg/week	3rd week (April 2021) Kg/week	4th week (April 2021) kg/week	Total amount In a month	percent coverage each types of waste (%)
Newspaper waste	1076.75 kg/week	987 kg/week	1134 kg/week	1109.25 kg/week	4307 kg/ month	44.98%
Tear of waste	788.5 kg/week	814 kg/week	678 kg/week	873.5 kg/week	3154 kg/month	32.94%
Reel-end waste	286.25kg/week	197kg/week	349.75kg/week	312 kg/week	1145 kg/ month	11.95%
Sweep waste	190 kg/week	150.5kg/week	205.5 kg/week	56 kg/week	602 kg/month	6.28%
Other waste	75.5 kg/week	80 kg/week	42 kg/week	104.5 kg/week	302 kg/month	3.15%
Total					9574kg/month	100%

Table 2: Data Collection on Focused area Wastes for one Month (kilogram per week)

From the above table we understand that news-paper waste cover the major portion among other printing wastes. So based on the data mentioned above we can develop Pareto diagram as follows:

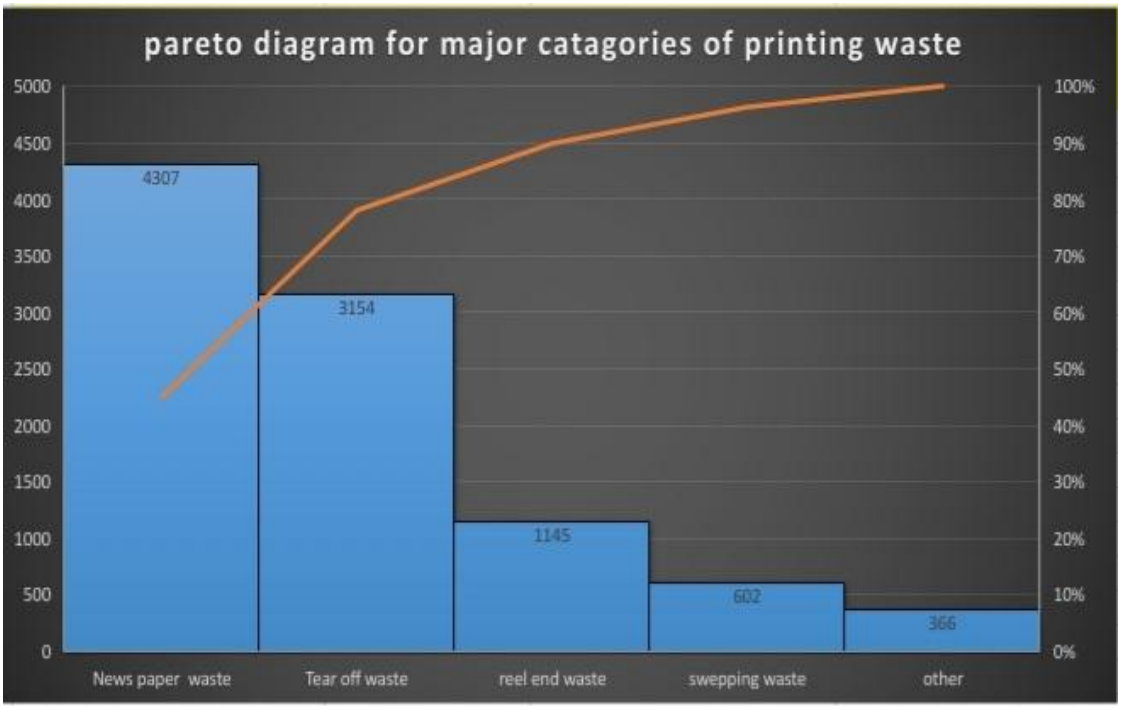

Figure 4: Pareto diagram analysis

From above Pareto diagram concludes that news-paper waste is the critical factor for Berhanena selam printing enterprise. The Pareto chart also shows that there is huge newspaper waste, i.e. 4307Kg/month, and the organization needs to focus on reducing the newspaper waste.

4.6. Root Cause Analysis for News-Paper Waste (Critical Factor)

Under this section cause-and-effect diagram for News-paper waste developed through brainstorming. In brainstorming session, different ideas had been taken from relevant experts about the excessive wastage of News-paper in the company. This active communication with concerned experts helps in building of ideas that leads to fantastic ideas. Once ideas are generated then it is displayed by using effective quality tools called "Cause and effect diagram" that allows people to easily see the relationship between factors. The developed cause-and-effect diagram presented as follows:

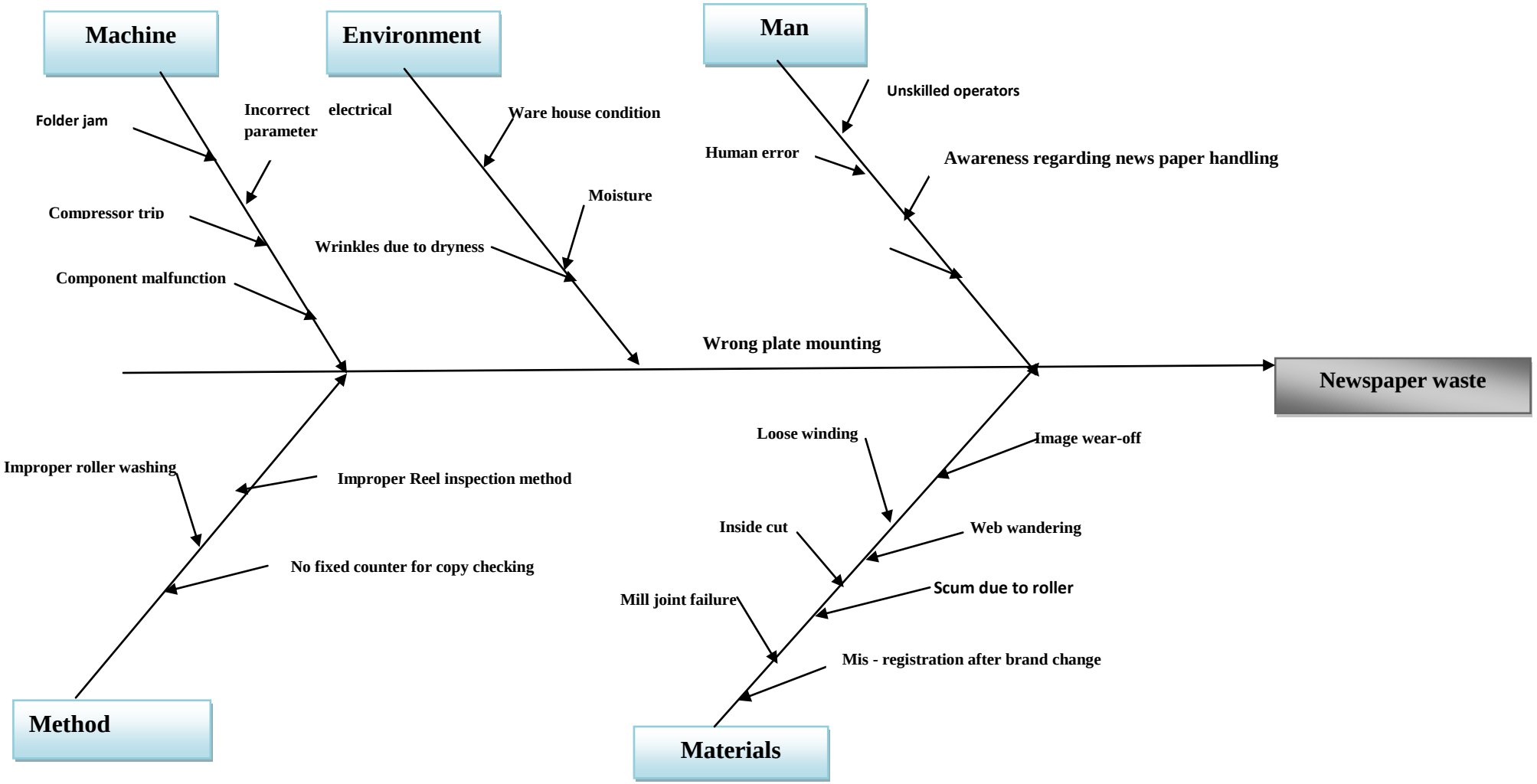

Figure 5: Cause and Effect Diagram for Newspaper waste

4.7. Brief Explanation about the Cause and Effect Diagram Showed in the Above

The a bove cause and effect diagram was developed through brainstorming session among relevant experts for identifying the possible sub-causes for each major categories of possible causes that leading to Newspaper waste(main focused area of waste). Let see these one by one im details:

Investigation on possible sub-causes relating to machine: in this area brainstorming was done to machine operators, maintenance experts and electrical technician then the following ideas developed such as web breaks,Folder jam, Incorrect tension values, Compressor problem, incorrect electrical parameters, and component malfunction. From these identified possible causes folder jam was significant sub causes that mostly occured this is due to sensor not properly activated and loose sheet after splice and also web break between operation was significant sub- causes.

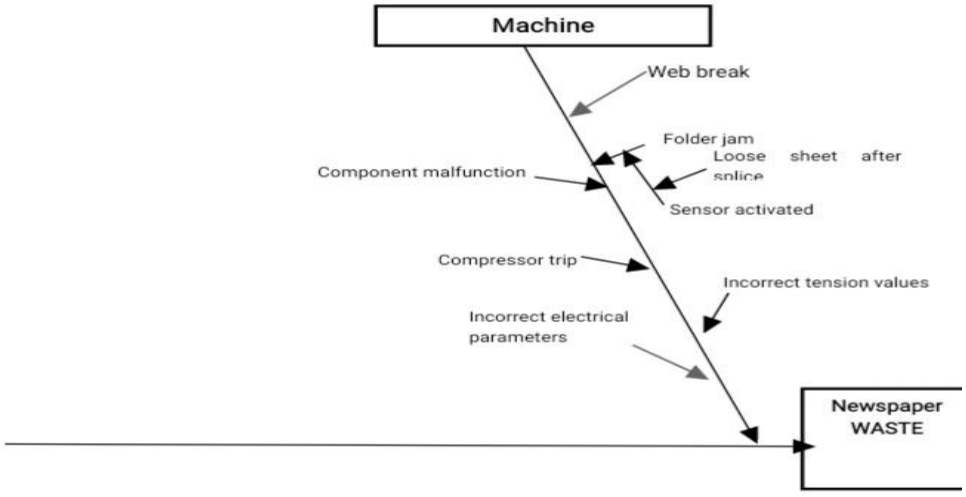

Figure 6: Investigation on possible sub-causes relating to machine

Invastigation on the possible sub-causes relating to man : in this study main core ideas developed through brainstorming with relevant experts such as printing department human resources employers and workers that highly attached with press operation then investigated the possible sub-causes relating to man those are awareness regarding newsprint handling, unskilled operators, using wrong plate, and unexpected human

error.from these investigated possible causes awareness regarding newsprint handling is significant this is due to lack of scientific procedures for reel.

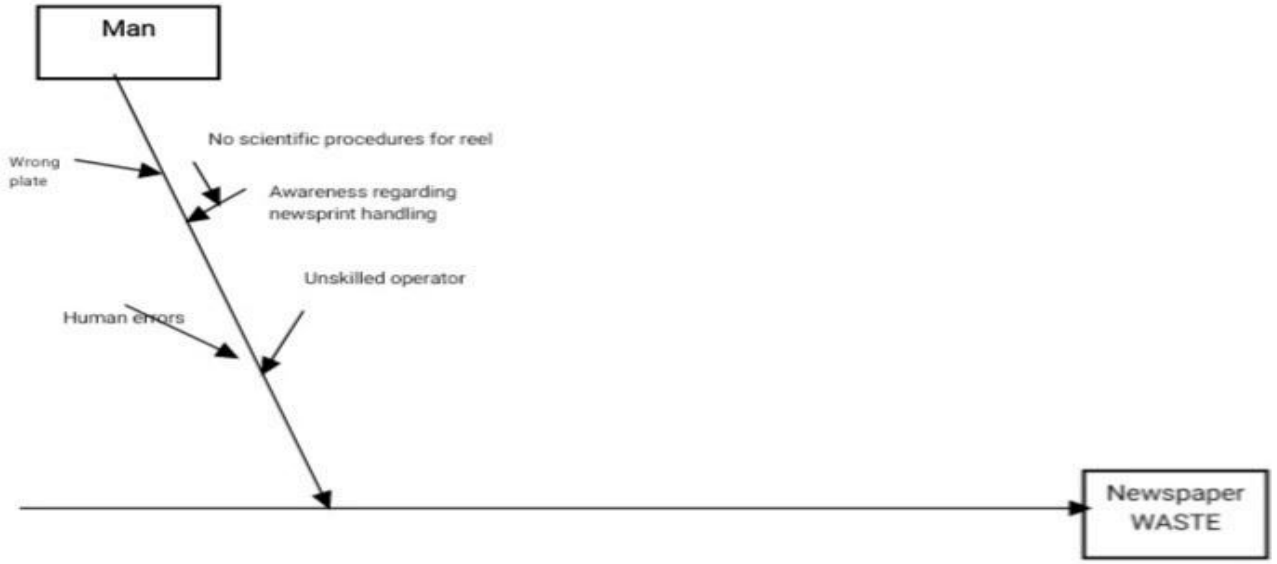

Figure 7: Invastigation on the possible sub-causes relating to man

Investigation on the possible sub-causes relating to environment : in this area brainstorming was done with concerned experts works specifically relating to environmental issues and identified some important sub-causes under major environment cause. Those are unsuitable warehouse conditions, wrinkles due to dryness, and moisture.

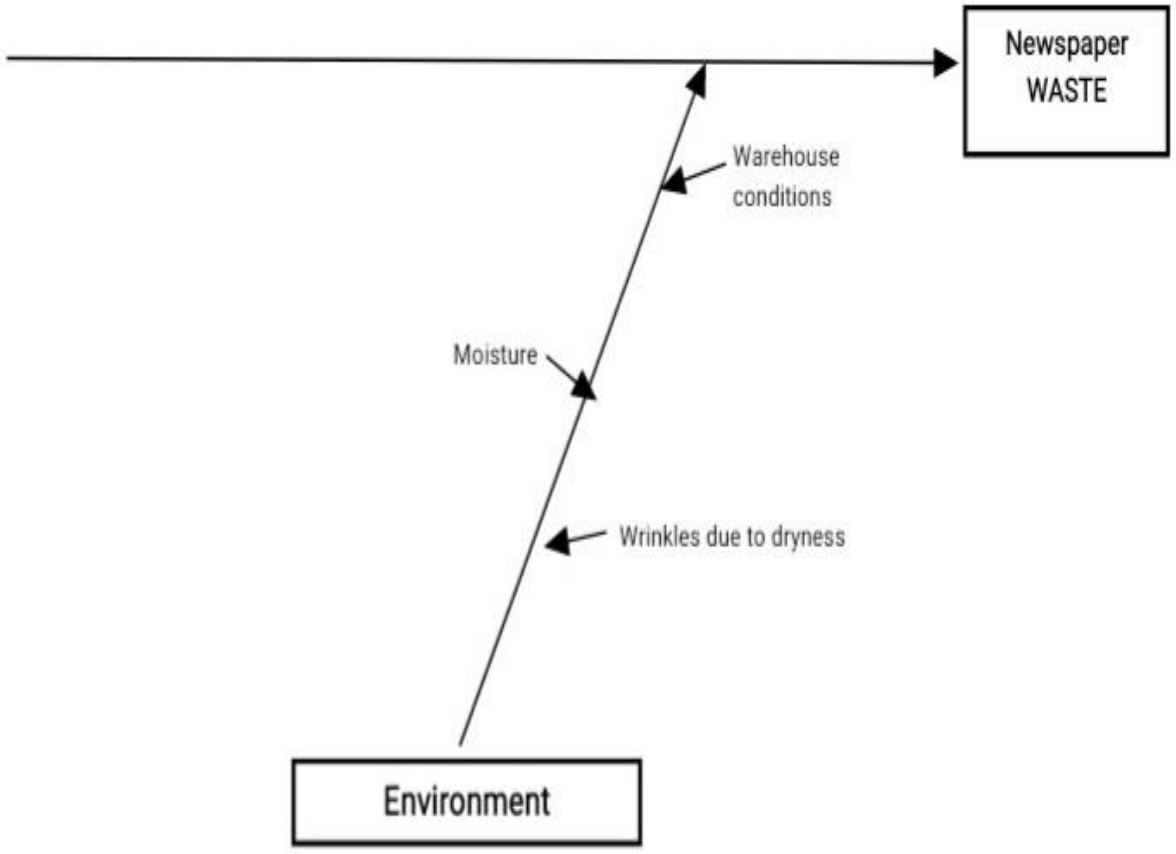

Figure 8: Investigation on the possible sub-causes relating to environment

Investigation on the possible sub-causes relating to Materials : during brainstorming session with experienced experts (at least more than ten years experience) such important ideas developed for the sub-causes under major category of materials.some of them are image wear-off, out off round reels, Mis-registration after brand change, mill joint failure , inside sticky reel, and scum due to ageing. Among them out off round reels is significant cause because of loose of reel cushions during unloading.

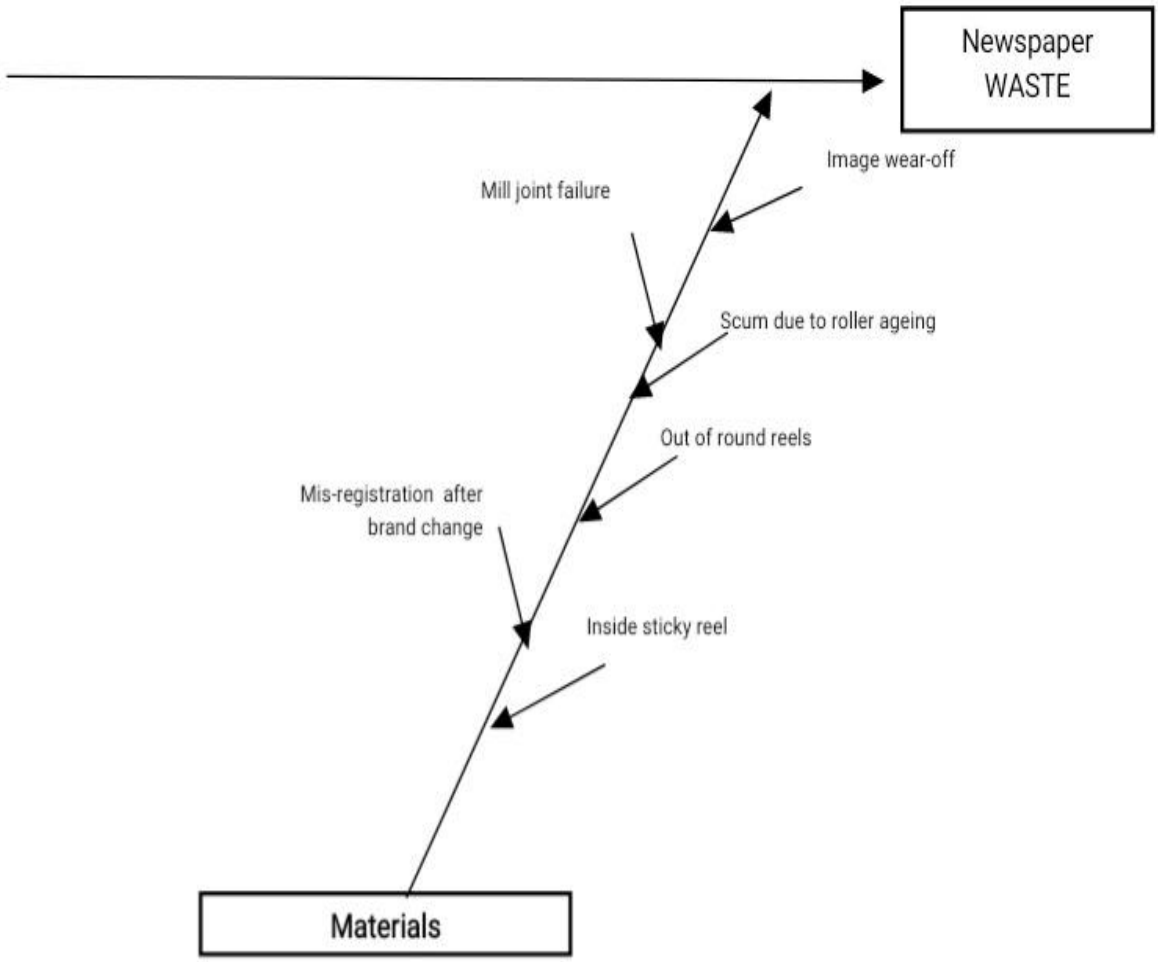

Figure 9: Investigation on the possible sub-causes relating to Materials

Investigation of the possible sub-causes relating to method : this section needed not only brainstorming rather used focused group discussions with responsible experts such as manager of printing department and team leaders in press operation and also reviewed literature*(eg.Newsprint waste reduction* by *Jagran Prakashan Limited, Noida)*were made for getting effect possible sub-causes for main category of method. Some of them are Reel inspection method, No fixed counter for copy checking, scum due to roller washing. Among this No fixed counter for copy checking is significant.

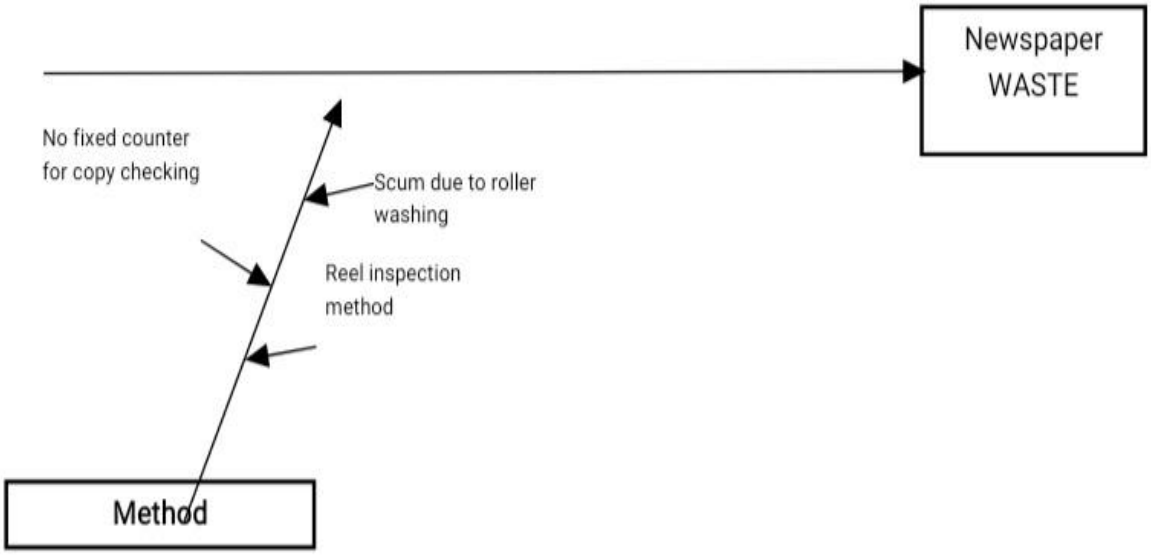

Figure 10: Investigation of the possible sub-causes relating to method

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1. Recommendation and suggested improvement solutions

As shown in the above cause and effect diagram we understand that there are various causes and sub-causes leading to newspaper waste among those in this section the research study gave some important recommendation and suggested improvement solutions to the company for selected major causes leading to Newspaper waste. Major causes for Newspaper waste and recommendation with suggested improvement solutions listed belows in table form.

No.	Major causes for Newspaper waste	Recommendation and suggested improvement solutions listed belows in table form.
1	**Man**	• Must have skill in identifying causes of defects before it occurs or provide training • Be able to identify defects quickly and accurately and how to remedy them /must have been provided. • Must have attention and good attitude towards quality.
2	**Materials**	• Use appropriate quality raw materials and Check contamination of the materials. • The poor application of cause and effects diagrams, Pareto diagrams, check sheet, control chart and other quality improvement tools calls for a need to restructure the policies of the company.
3	**Machine**	• Preventive maintenance to ensure machine and equipment always in good conditions • Avoid power interruption or must have reserve power supply while interruption occurs. • Batching scale/ balances has correct calibration and improving set up of production changes and • Automated production machine and equipment used, not used labor based.

4	**Environment**	• properly conditioning newsprint (raw paper for production of newspaper) to pressroom temperature and humidity before printing, and training employees to use newsprint properly.
5	**Method**	• Regularly provide training to the operator related to machine handling especially related roller setting • Improving accuracy of counting methods to reduce excess quantities printed to accommodate inaccuracies • Check the quality of the reel before mounting on a machine for printing. • Assigned fixed counter for copy checking

Table 3: Recommendation and suggested improvement solutions

5.2. Another suggested alternative methods for Minimizing current Existing waste

Alternative method that recommended for the company is adopted quality circle(organized best team).At the company it is important to establish a team, in order for reduction activities If a team responsible for waste minimization is assembled, it should consists of employees from different departments within the organization, as paper waste is a cross-functional issue, this to reduce risks of suboptimal changes. Furthermore, the team leader should be in a managing position in order to obtain a high degree of authority within the organization and swifter communication with management.

An other alternative method recomemded for the company is adopting kaizen discipline. Because of Reducing(minimizing) paper waste is a complex problem to which there is no single and easy quick-fix solution. To approach sustainability and reduce paper waste a systematic and continuous application of waste reduction methods is required that called kaizen. If the company adopt kaizen surely it becomes a beneficial to minimize waste at minimum level.

5.3. Conclusion

This research study aims at answering the formulated research questions of the study.

Research question 1: What are the main waste types in the printing department of the company?

Based on observations and measurements it can be concluded that the main waste types found in the printing department were Tear-off waste, newspaper waste, Reel-end waste , and sweeping waste among those newspaper waste acconted 44.98% and Tear-off waste accounted 32.94%.

Research question 2: What are the main causes of paper waste generation at the company?

After having analyzed the current state at the company a number of causes for the generation of paper waste have been identified. First of all a lack of focus on lowering paper consumption and reducing paper waste has led to the issue being neglected, and thereby unprioritized within the organization. This has created a mindset were all paper discarding's are viewed as necessary and a natural outcome of current production conditions on a shop-floor leve**l.** And also the research study tried to investigate a possible potential causes for paper waste generation in the printing department through brainstorming plus interviewing with relevant experts hence, relating to man awareness regarding newsprint handling, unskilled operators, using wrong plate, and unexpected human error. relating to method lack of Reel inspection method, No fixed counter for copy checking, scum due to roller washing. Relating to material image wear-off, out off round reels, Mis-registration after brand change, mill joint failure , inside sticky reel, and scum due to ageing. Relating to environment unsuitable warehouse conditions, wrinkles due to dryness, and moisture and relating to machine web breaks, Folder jam, Incorrect tension values, Compressor problem, incorrect electrical parameters, and component malfunction.

Research question 3: What actions need to be taken by the company in order to reduce current paper

Reducing paper waste needs to become prioritized within the organization if real improvements are to be made, therefore a cross-functional waste reduction team should be established to drive change and communicate the economic and environmental impacts of current paper waste quantities and connected reduction goals and targets. The view of paper waste as necessary needs to be challenged and commitment towards waste reduction established throughout the organization. Ways of achieving this include clearly communicating the rationale behind reducing paper waste and the objectives of the environmental strategy to all personnel. Moreover, incentivizing waste reduction through reward systems and celebrating progress is important. Feedback needs to be given to maintain participation and motivation in connection to reduction efforts. Communication is key to create awareness and drive change, and cross functionality reduces risk of suboptimal solutions being implemented. Furthermore, reduction activities should become an integral part of the current environmental management system, as this provides a decision-making structure, supports continuous improvements, and allocates focus to the specific environmental problem of paper waste.

Accountability for paper waste generation also needs to be established in order to drive change and reduce waste quantities. Therefore performance indicators should be implemented on production level, and department managers should be held responsible for reporting these figures to the waste reduction team, and for setting realistic goals and targets. This creates ownership and helps to change mindsets. Reduction activities also need to be incorporated into job descriptions on a shop-floor level, and operators need to be made aware of waste goals and targets. Furthermore, performance indicators should be displayed to and dis cussed with operators to generate improvement alternatives, since people with process knowledge often generate the best improvement ideas. Moreover, if practices are changed proper training is important, in order to assure that the reasons for changes are clear and that changes are fully understood. Finally the recommended solution significant role for minimizing huge amount printing wastes.

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APPENDICE

APPENDEX-A

St. Mary's University Graduate School

Institute of Quality and Productivity Management

QUESTIONAIRE

Survey questionnaire for a study on waste minimization through quality improvement tools in Berhanena selam printing enterprise . Dear Sir/Madam, I am student of Master of Quality and Productivity Management (QMP) in St. Marys University. The following research is part of my QMP study and conducted for purely academic purposes. The purpose of the research is to find out the current existing major causes of wastes and put forward recommended and suggested solutions to minimize the quantities of wastes All the Information collected through the questionnaire will be used only for contribution to knowledge and kept secret/confidencial. Please ensure that you mark all the given statements otherwise incomplete responses will not fulfill researcher requirements.

To this end, kindly request you to answer the following short questions regarding with the stated objective. It will take no longer than 15 minutes of your time. Your response is utmost important to me. Therefore, you're genuine, honest and prompt response is available input for the quality and successful completion of the project research paper.

General Instruction

- There is no need of writing your name.
- In all case where answers options are available, please make mark(X) in the appropriate place.

Part1: General Information

This section of questionnaire refers to general information about the respondent. The information will allow me to compare groups of respondent.

1. **Gender**: Male_____ Female_____

2. Age: <20..... 21-30..... 31-45..... >45 .....

3. Qualification: Diploma_____ First Degree_____ Masters_____ others more than_____

4. Number of years you have served the enterprise: Less than 5 years..... 6-10 Years.....11-15 years.....More than 15 years.....

Part II: GENERAL INFORMATION ON COMPANY

5. please list down, What are the main waste types in the printing department of the company?

1.....

2.....

3.....

4.....

6. Please list down, What are root causes of main printing waste generation at the company?

1.....

2.....

3.....

4.....

7.Please list down, What actions need to be taken by the company in order to reduce the main identified paper waste company?

1.....

2.....

3.....

4.....

8.Which type of waste is mostly occurs in the printing department? (Please Rank the in their degree of occurrence) (1; Low 2; Moderate 3; High, 4; Very High)

	1	2	3	4
Newspaper waste				
Tear-off waste				
Sweeping waste				
Reel end waste				

9. What is the the possible causes for newspaper waste in the printing department? In Your opinion, what is the level contribution of the following causes for newspaper waste in the printing department ? 1; Low, 2; Moderate, 3; High, 4; Very high

	1	2	3	4
Environment				
Machines				
Materials				
Man /labour				
Methods				

10.What are the causes that related to people or man for newspaper waste(Tick for more than one answer is allowed)

- Lack of document properly interpreted.
- Lack of training.
- Lack of understanding information.
- Lack of guideline judgment available

Other (please specify)_____.

11 . Have you try to minimize wastes as much as possible: yes.....No.....

12. Please rank your familiarity with the following quality improvement basic tools in your company, 1: Not familiar, 2: Basic understanding, 3: Well Familiar, 4: Expert

	1	2	3	4
Cause and effect/Ishikawa/ fishbone diagram				
Check sheets				
Histograms				
Pareto analysis				
Scatter diagrams				
Flow charts/diagrams				
Control Charts				

Part III:

13. Assess the main causes and sub-causes for Newspaper wastes in the printing department.

Under this section questionnaires prepared to collect data about the main causes or factors for Newspapaper waste in printing department. Please indicate the extent to which you agree or disagree with each statement by Ticking(X) on correspondent number. Higher number indicates higher level of agreements. Choose only one answer for each statement.					
General approaches 1. Strongly Disagree (2)Disagree (3)Neutral (4)Agree (5) Strongly Agree					
MACHINE RELATED FACTORS	1	2	3	4	5
Was the correct tool used?					
Does the environment affect the equipment?					
Is the equipment being properly maintained (i.e., daily/weekly/monthly preventative maintenance schedule					
Is the machine the right application for the given job					
Are all controls including emergency stop button clearly labeled and/or color-coded or size differentiated?					
MATERIAL RELATED FACTORS					
Was the material properly tested?					
Were quality requirements adequate for part function?					
Was the material handled properly (stored, dispensed, used & disposed?					
Was the material contaminated?					
ENVIROMENT RELATED FACTORS					
Does the process run in a controlled environment?					
Is the process affected by humidity, vibration, noise, lighting etc.					
Is the process affected by temperature changes over the course of a day?					
METHODS RELATED FACTORS					
Were the workers trained properly in the procedure?					
Are the work instructions clearly written?					
Are mistake-proofing devices/techniques employed?					

Thank you for your collaboration and sacrifice of precious time!!!

APPENDEX-B

CHECK SHEET FOR COLLECTING THE AMOUNT OF MAJOR TYPES OF WASTES

LOCATION : BERHANENA SELAM PRINTING ENTERPRISE, ADDISS ABABA

PURPOSE : Investigate or measure the amount of main types waste occured in Berhanena selam printing department.

STUDY PERIOD : April, 01-31/04/2021

DATA COLLECTED BY :----------DATE----------

CHECKED BY: ---------- SIGN----------

APPROVED BY: ---------- SIGN----------

Focused area of wastes	1st week(April 2021) Kg/week	2nd week (April 2021) Kg/week	3rd week (April 2021) Kg/week	4th week (April 2021) kg/week	Total amount In a month	percent coverage each types of waste (%)
Newspaper waste						
Tear of waste						
Reel-end waste						
Sweep waste						
Other waste						
Total						