

# Designing Efforts to Increase the Efficiency of Water Recycling Energy use in the Production Department using Why Why Analysis Methods and Fishbone Diagrams to Realize the Application of Green Manufacturing in the Carton Box Packaging Industry

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**Abstract:-** Green manufacturing as one of the environmental protection and preservation measures that began to be applied in the industrial world in the modern era, improving energy efficiency within the company is a good thing to do, especially in carton box manufacturing companies, many benefits are obtained if the company can control its energy source. Energy sources are the main capital that is the basis for the company's movement, one of the energy sources owned by the carton box manufacturing company and the company's basic needs are water, water holds the basic elements of life within the scope of the company, the use of water is also absolutely necessary in the company environment. Therefore, efficient use of water is absolutely necessary to increase company profits and protect nature and the surrounding environment. This study aims to design efforts to implement green manufacturing in carton box companies by maximizing the use of recycled water processed and reused in the production section for carton printing needs, this can affect the use of clean water which can reduce company capital and can protect the environment because liquid waste from treatment can be maximized for reuse.

**Keywords:-** Water resources; Energy efficiency and Green Manufacturing.

## I. INTRODUCTION

The carton box finishing industry plays an important role in the rotation of the wheels of the economy in Indonesia, as one of the components contained in the product, carton box finish plays an important role in maintaining product quality, adding a good image to the product and ensuring product hygiene before it is received into the hands of consumers. The cardboard production process has the main component in the form of paper which is processed in such a way through corrugated, printing and finishing processes in which there is a chemical process to produce products that are guaranteed quality.

Chemicals used in the production process must have a material safety data sheet (MSDS) which has 16 main points, where the MSDS explains all material content, usage guidelines, handling procedures and if abnormal conditions can be resolved immediately then in line with the objectives of Occupational Safety and Health (K3) in the company environment.

In today's modern era, it is important for every company to form an environmentally friendly industry as emphasized by laws and regulations, namely Law number 3 of 2014 in article 30 where the industrial world is required to utilize natural resources more efficiently, environmentally friendly and sustainably. Therefore, it is important for every company to have a vision and mission to implement green manufacturing in every line of its operations.

This is in line with the company's goal of being formed, where the company needs to have 3P in carrying out its activities, 3P stands for Provit (Profit), People (Humanity) and Planet (Earth and Environment).

The purpose of this study is to find out the main causes of the high use of clean water in the printing production department, provide an overview and suggestions for improving the use and reuse of water energy from liquid waste treatment for the needs of the printing production department and to realize a green manufacturing program that will bring many benefits to companies and the environment by reducing the volume of liquid waste discharge directly into river bodies though the company already has a wastewater disposal permit (WWTP).

In this study, referring to the design of efforts to increase the efficiency of using water recycle in the carton box packaging industry, which will have an impact on reducing costs, controlling clean water resources and environmental protection, with the application of water reuse treated by ink waste in the production process, the use of clean water in the production process can be replaced, In

addition, the disposal of liquid waste in nature can also be minimized.

## II. LITERATURE STUDY

### A. Green Manufacturing

Green manufacturing is a method in manufacturing to minimize waste and pollution through product and process design with the main goal being for a sustainable environment. Green manufacturing processes involve investing in better production processes, substituting the latest sources for limited, recyclable, companies must decide whether to make or buy a product. Apply the principles of environmental preservation and energy efficiency in production activities, with the aim of reducing waste in the industrial sector, saving energy, overcoming resource scarcity, and reducing the impact of environmental pollution.

### B. Energy Efficiency

Energy Efficiency is an attempt to reduce the amount of energy required in the use of energy-related equipment or systems. Energy efficiency can also mean systematic, planned, and concerted efforts to: Conserve domestic energy resources (energy diversification) Increase the efficiency of energy resource utilization.

### C. Why-Why Analysis

Why-why analysis or 5 Whys is an approach to investigating the root of a problem by asking the "why" repeatedly to find a solution. This method serves as a root cause analysis tool in problem solving. This tool helps determine the cause of nonconformities in processes or products, allowing for more effective improvement.

The why-why analysis method was developed by Sakichi Toyoda who is the founder and developer of Toyota which is a leading automotive company in the world, then this method is used within Toyota Motor Corporation. In the 1970s, the why-why analysis method was popularized by Toyota Production Systems.

### D. Fishbone diagram

Ishikawa diagrams (also called fishbone diagrams) are diagrams that show the cause of certain events. This diagram was first introduced by Kaoru Ishikawa (1968). The most common use of Ishikawa diagrams is to prevent product defects and improve product quality. Ishikawa diagrams can help identify factors that significantly influence an event.

A fishbone diagram will identify various potential causes of a single effect or problem, and analyze those problems through brainstorming sessions. Problems will be broken down into a number of related categories, including humans, materials, machines, procedures, policies, and so on. Each category has a reason that needs to be elaborated through brainstorming sessions.

## III. RESEARCH METHODS

The research methods used tend to be quantitative research methods, quantitative research methods emphasize aspects of objective measurements and data directly in the field, namely by making direct observations measuring and collecting data on the use of clean water and the use of water treatment / water recycle at carton box companies. Meanwhile, before implementing the green manufacturing concept, the company already has a wastewater disposal permit (WWTP) to dispose of treated liquid waste into nature with water conditions that are in accordance with predetermined water quality standards, including water pH, Chemical of Demand (COD) / dissolved chemical levels in water, Biological Matter of Demand (BOD) / Biological levels dissolved in water, Total Suspended Solids (TSS), oxygen, oil or fat and so on.

Based on the Regulation of the Minister of Environment No. 5 of 2014 explains that wastewater quality standards are COD levels should not exceed 100 milligrams/liter, BOD should not exceed 150 milligrams/liter, total water pH should be at least 6 and maximum 9, TSS levels should not exceed 30 milligrams/liter and oil and fat levels are a maximum of 5 milligrams/liter, All applicable standards aim to maintain the quality of water to be flowed into river bodies and to maintain the survival of biota and the environment.

The survival of biota and nature and the environment in it needs to be the attention of all stakeholders because it has an important role in the survival of society and in general for the survival of mankind, because water is a basic element of human life, water has great control over the life of mankind, It is very important to maintain the quality of water flowing in the environment.

Through design based on the why-why analysis method and fishbone diagram, it is known that by reusing wastewater from water treatment/recycling can reduce the use of clean water which has an impact on reducing capital/costs in the first 3 months after the application of the design in this study, through the why-why analysis method and fishbone diagram It can also be seen that waste that occurs in the production area can be minimized.

The primary data used in this study were sourced from direct observations of clean water use and wastewater treatment as outlined in daily records, while the secondary data used in this study were sourced from monthly reports on clean water use and wastewater treatment taken 3 months before and 3 months after the research design and application.

To support this research, a literature study was conducted on the theory of green manufacturing and energy efficiency and to gain an understanding of research methods. To obtain optimal results, systematic and structured steps were carried out in this study.

The research stage starts from collecting data through daily recording within 3 months before the company applies the concept of green manufacturing for water use, the second stage is to measure waste that occurs in the

production area which causes high costs experienced by the company. From the data collected, problems were found in the company's operational activities. To find out the flow of research, it can be seen in figure 1.

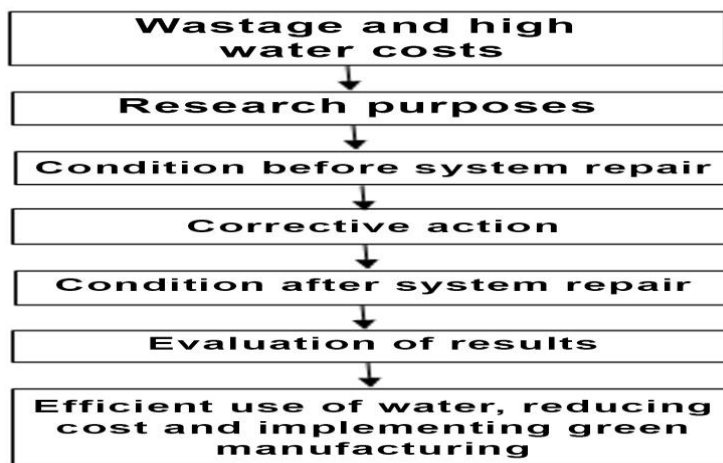


Fig. 1: Stages of research

The third stage is to conduct a focus group discussion (FGD) conducted by the operational team by involving teams in the production area and WWTP to find out the main causes of increasing the use of clean water in the printing section in the production area.

In the next stage, the researcher explained the improvement design and proposal for the use of recycled water to the production area to increase the visibility of clean water use in the production department and to carry out green manufacturing in carton box manufacturing companies. The last stage is to evaluate the application of this design to production results and performance, this is also part of the application of green manufacturing, it will be seen that the effectiveness of the application of the improvement results will affect the reduction of liquid waste disposal directly into river bodies and reduce the use of clean water which will directly affect the cost and capital of carton box manufacturing companies related to the use of clean water.

**IV. RESULTS AND DISCUSSION**

The focus of this research was carried out on carton box manufacturing companies, precisely in the production and WWTP section. The research was conducted because the use of clean water is quite high in the printing production section and the disposal of liquid waste treatment results into river bodies which must be minimized even though they already have a wastewater disposal permit (WWTP) to carry out green manufacturing needs in the industrial sector. All problems that occur need to be overcome and followed up to get optimal results and can be useful for the company.

*A. Early Identification*

Box cardboard manufacturing companies are companies engaged in the production of cardboard-based packaging, in their operations the company requires large amounts of water for the production process and its utilization, based on the data collected the company has abundant water resources in the WWTP department whose existence needs to be considered for further use, in table 1 will be explained water usage data at carton box manufacturing companies in December 2022 to by February 2023.

Table 1: Water Usage Data

Moon	Clean Water (M3)	Treated Water (M3)	Usage Percentage (%)
December 2022	2635	1399	65/35
January 2023	2584	2049	55/45
February 2023	2317	1929	54/46

Based on the data collected above, it can be seen that the use of clean water is greater than the expenditure of water treated with sewage. Therefore, research steps were carried out to determine the causes of the high use of clean water and to describe the layout of clean water use and wastewater flow from the production process.

The first step in this study is direct observation in the field involving representatives of the printing production department and representatives of the WWTP department which is the focus of research to determine the flow of the clean water distribution process to the production department using FGD.

Representatives of printing and WWTP production are experienced personnel in controlling and operating their respective jobs, consisting of 4 internal companies and 1

external company that contribute to analyzing the flow of clean water distribution to the printing production department.

Table 2: Tim Focus Group Discussion (FGD)

	Age (Years)	Work Experience (Years)	Department	Special Skills	Information
FGD1	47	25	Engineering Manager &; Production	Corrugated Techniques, Printing &; Techniques	Internal
FGD2	43	25	Printing Supervisor	Printing Production	Internal
FGD3	33	15	Engineering Supervisor	Technique Technique	Internal
FGD4	28	10	WWTP Leader	IPAL and Clean Water	Internal
FGD5	22	5	General Affairs Leader	Building & Clean Water	External

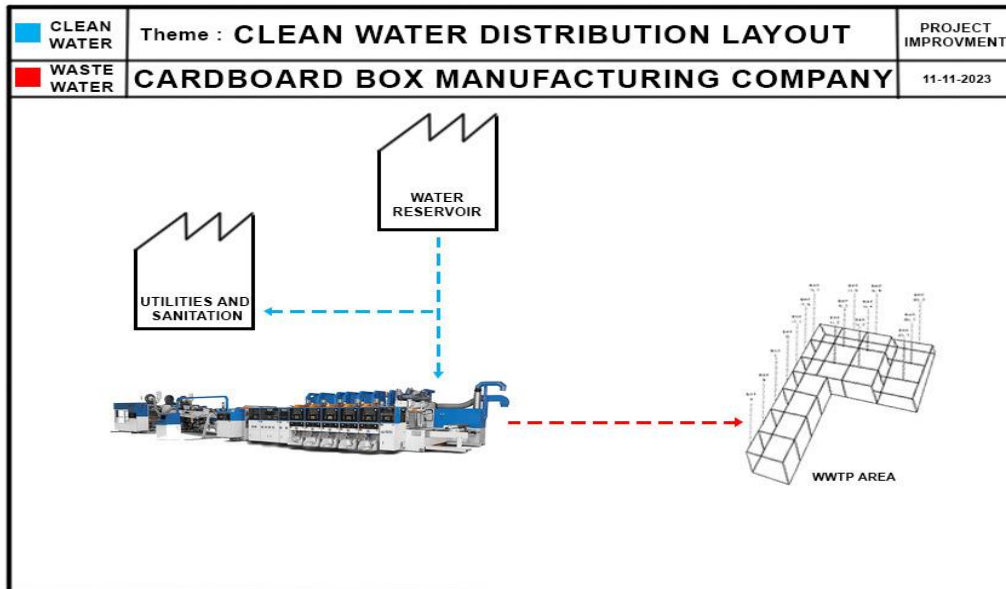


Fig. 2: Clean Water Distribution Layout

The FGD agenda discusses the flow of the clean water distribution process that flows to the printing production department needed for the ink mixing process before being used for the color and image printing process on carton boxes. In addition, the FGD also discussed the design of the water retreatment distribution process in the WWTP department, which enables green manufacturing processes in the corporate environment.

Briefly, the wastewater treatment process in the carton box manufacturing company environment starts from wastewater entering the liquid waste reservoir, at this stage the water will be precipitated for 12 hours to reduce the dirt and sludge carried during the drainage process to the WWTP department, after the settling process, the wastewater is then flowed using an electric pump to the treatment basin. The processing process in tubs C and D takes place chemically, where alum liquid waste (Al<sub>2</sub>(SO<sub>4</sub>)<sub>2</sub>.12H<sub>2</sub>O is added) which functions to purify water, lime (Ca (OH) <sub>2</sub>) which functions to balance Ph levels in water and Anionic which serves to help flocculation / binding contaminants and SS in water.

In the procedure listed, in the process of processing liquid waste for tubs with a water capacity of 1000 Ltr, alum as much as 2 Kg, lime as much as 2 Kg and anionic as much as 1/4 Kg, the mixing process is carried out evenly and gradually, the treated water is then flowed into inlet 1 to inlet 9 tubs and drainage is carried out to outlet 1 to channel 3, In inlet and outlet basins, water is drained using a graffiti process.

After going through the graphitation process in the inlet and outlet basins, wastewater is then flowed using an electric pump to enter the sand filter tube and carbon filter to ensure water quality is maintained both chemically and biologically, can be seen in figure 3 documentation of the liquid waste treatment process at the carton box manufacturing company.

This can be seen in figure 3 of the liquid waste treatment process carried out at a carton box manufacturing company, where the operator carries out a alum type chemical mixing process that serves to purify liquid waste.





Fig. 3: Wastewater Treatment Process

The treatment results must be in accordance with the permitted water quality standards, including referring to Ph, BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand) and color density in water, all of which aim to maintain the quality of treated water that will flow into river bodies in accordance with the rules listed in the wastewater disposal permit (WWTP).

**B. Why-Why Analysis**

The results of the why-why analysis method used in this study are to determine the main causes of the high use of

clean water in the printing production section, consisting of 5 whys that describe problems that continue to narrow until there is a solution to the problems that occur, and suggestions are given for improving existing problems. This can be seen from figure 4 of problems that occur in carton box manufacturing companies.

Figure 4 shows the results of the why-why analysis before the repair process occurs, where there is an elaboration of the causes of the high use of clean water in the printing production section.

Case	Why 1	Why 2	Why 3	Why: 4	Why 5
High consumption of clean water leads to huge costs	There are uses in the printing process to mix ink and clean prints.	The use of clean water is often done in the printing process because 1 machine produces 4 different customer product articles every day.	Mixing ink using clean water is often used because in 1 day the printing machine can consume up to 18 pail of ink.	Clean water consumption is absolutely necessary in the ratio of 1 bucket of ink to 1/2 bucket of clean water to guarantee dilution of ink.	Clean water is also required for the die cleaning process and rubber molding after use to maintain the quality and cleanliness of the equipment.
Repair				Mixing ink using treated wastewater in WWTP department	Ink cleaning using treated wastewater in WWTP department
Prevention				Regular cleaning of the machine, regular maintenance and optimal use of water.	Optimal water use and ensure the quality of wastewater treatment results.

Fig. 4: Why-Why Analysis Method

**C. Repair Phase**

The repair phase was carried out due to the high use of clean water due to the use of water in the printing production section. Improvements are aimed at reducing the use of clean water for the printing production process and minimizing the disposal of treated liquid waste in river bodies to carry out the purpose of implementing green manufacturing.

**D. Fishbone diagram**

At this stage the fishbone diagram is used as a tool to identify improvements in the high use of clean water in the production department, this can be seen from figure 5 of the use of fishbone diagrams in terms of the high use of clean water in the production department.

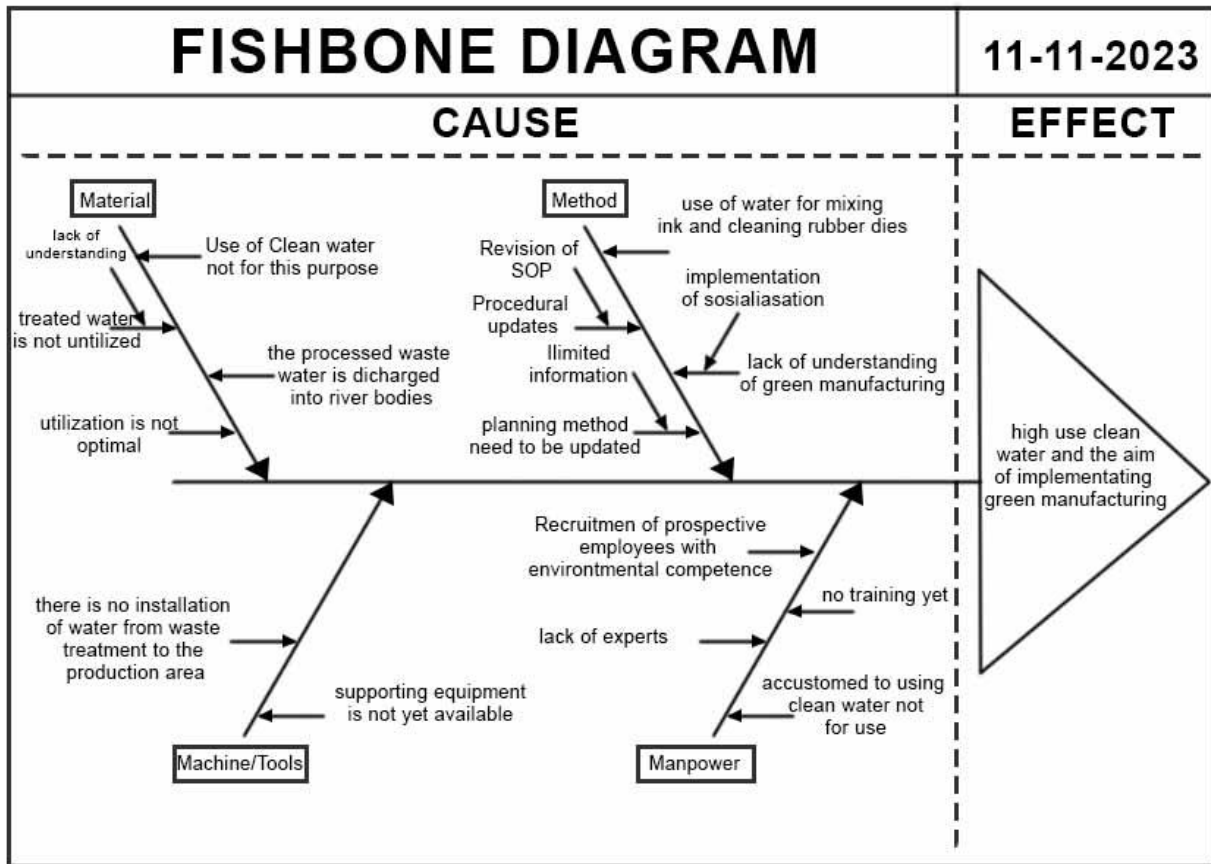


Fig. 5: Fishbone Diagram

Based on the identification of the causes of high use of clean water and the identification of proposed improvement suggestions to minimize the use of clean water and to implement green manufacturing principles in carton box manufacturing enterprises, there is a proposed improvement plan outlined in figure 6.

In figure 6 described the reuse of recycled treated water in the WWTP department for reuse in the printing production department, the facility added to the improvement plan of this study is to install the water

installation from the outlet of the WWTP department to the flexo printing machine.

Before heading to the flexo printing machine, water from liquid waste treatment is collected using a fountain with a capacity of 10,500 liters to collect and ensure water availability before then flowing using an electric pump to the flexo printing machine, this continues with the use of water on the flexo printing machine which then produces waste to be treated in the WWTP department.

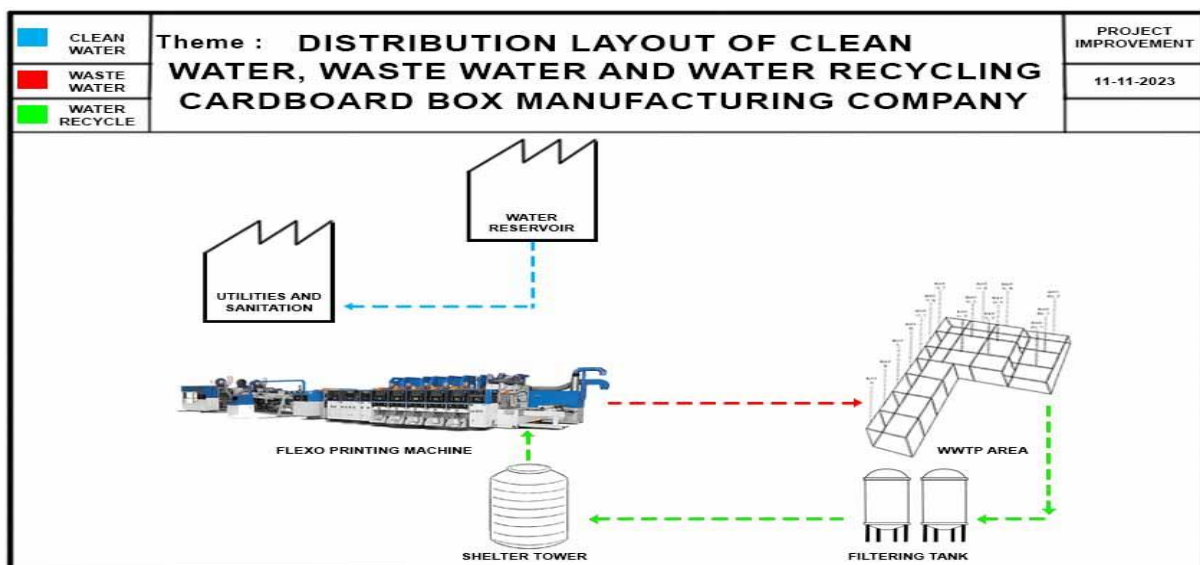


Fig. 6: Layout improvements

The application of corrective measures is applied to determine the effectiveness of planning the efficiency of clean water use and the application of green manufacturing in carton box companies, so that the data results contained in table 3 describe the use of clean water and the use of treated wastewater in carton box manufacturing companies. Repairs will begin in February 2023 involving the General

Affairs (GA) department, maintenance engineering department and WWTP department to implement wastewater installation installations treated into flexo printing machines.

Table 3 shows the percentage of clean water and treated wastewater taken from March 2023 to May 2023.

Table 2: Water Use Data After Repair

Month	Clean Water (M3)	Treated Water (M3)	Usage Percentage (%)
March 2023	1.296	2.722	32/68
April 2023	1.307	2.017	39/61
May 2023	1.300	2.037	39/61

Table 2 shows an improvement marked by a decrease in the use of clean water used by the printing production department, so it can be concluded that the importance of reusing water sources that can be utilized, maximum use of treated water can increase the efficiency of clean water use

and reduce water use costs in carton box manufacturing companies.

Based on the pre-research and post-research data collected, it is expressed in the comparison graph depicted in figure 7 below.

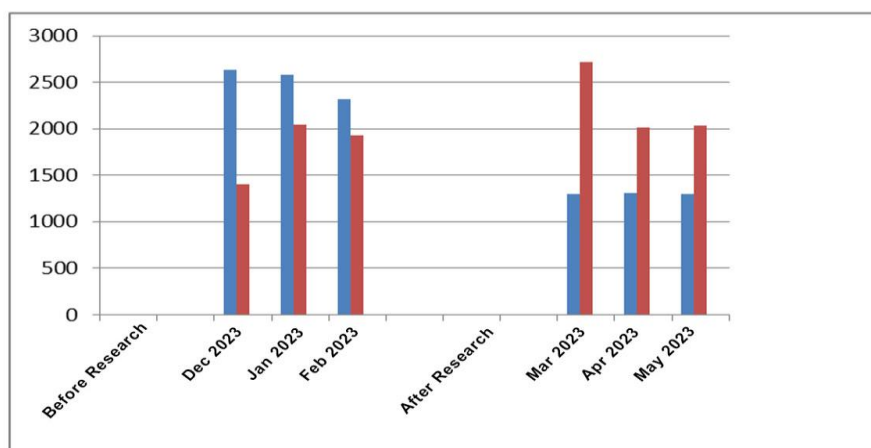


Fig. 7: Water Use Comparison Chart

However, it should be noted that periodic maintenance at each available facility such as screening tanks must be cleaned / back wash every 1x24 hours and filter media must be replaced every 6 months, pipe cleaning, pump maintenance and salty drainage cleaning in order to produce good wastewater treatment and suitable for use by the printing production department.

Repairs and maintenance need to be scheduled and carried out consistently in order to produce so that their application to carton box manufacturing companies can run smoothly and in the long run, consistency is absolutely necessary for the sustainability of the program and sustainable environmental protection efforts.

**V. CONCLUSION**

This research has identified the causes of the high use of clean water in the printing production department and provided advice and implementation of the application of green manufacturing in carton box manufacturing companies. Improvements are made by collecting data directly for 3 months before the advice is implemented and 3 months after the advice is implemented.

The purpose of this study is to find out the main causes of the high use of clean water in the printing production department, provide an overview and suggestions for improving the use and reuse of water energy from liquid waste treatment for the needs of the printing production department and to realize a green manufacturing program that will bring many benefits to companies and the environment by reducing the volume of liquid waste discharge directly into river bodies though the company already has a wastewater disposal permit (WWTP).

The results showed a significant decrease in the use of clean water in the printing production section and the use of water from liquid waste treatment was quite stable during the first 3 months of application, the use of water from liquid waste treatment needs to be accompanied by monitoring the results of treatment by monitoring water clarity, pH levels, Biological Of Demand (BOD), Chemical Of Demand (COD) and other water quality standard requirements.

However, in the study, there are investment costs incurred by management to implement water use plans from liquid waste treatment to the printing production

department that need to be studied further on the percentage of efficiency of clean water use costs with investment costs that have been incurred to compare and can be implemented in the long term and sustainably.

### REFERENCES

- [1]. Baiti Jannah, Ari Yanuar Ridwan, Rosad Ma'ali El Hadi. 2018. Design of Green Manufacturing System Performance Measurement Model Based on SCOR Model in Tannery Industry, Volume 05 Number 02.
- [2]. Hibarkah Kurnia, Indra Setiawan, Hernadewita. 2022. Integration of Lean and Green Manufacturing to Reduce Process Waste and Paper Waste in Employee Recruitment in the Manufacturing Industry in Indonesia. *Journal of Industrial Systems Engineering* Volume 11 No 2 - October 2022.
- [3]. Iranmanesh, M., Zailani, S., Hyun, S. S., Ali, M. H., & Kim, K. (2019). Impact of lean manufacturing practices on a company's sustainable performance: Lean culture as moderator. *Sustainability* (Switzerland), 11(4).
- [4]. Zeswita, Armein Lusi and Gustina Indriati. (2022). "Overview of Liquid Waste Treatment in Environmental Pollution Prevention at South Solok Regional Hospital". *Journal Encyclopedia*. Vol. 5 No. 1 issue 1 pp. 143-149 pp: 50 – 59
- [5]. Adyatama A, Handayani nu. Quality improvement using kaizen principles and 5 WHY Analysis: Case Study at Karawang Plant 1 Painting Shop, PT Toyota Motor Manufacturing Indonesia. *J@tiUndip J Tech Ind* 2018; 13(3).
- [6]. Susilawati D, Kanowski P. 2020. Cleaner production in Indonesia's pulp and paper sector: Improving sustainability and legality compliance in the value chain. *Journal of Clean Production*. 248:119259.
- [7]. Fitriyanti R. 2018. Application of clean production in pulp and paper industry. *Redox Journal*. 1(2):16–25
- [8]. Widyahening, CE 2018. The use of fishbone diagram learning techniques in improving students' reading skills. *Journal of Educational Communication*, 2(1), 11-19
- [9]. Hudori, M. 2020. Analysis of the process of receiving goods in the product warehouse using the concepts of Deming's View Process System, 5W+1H Principles and Five Whys Analysis. *Journal of Education Citra Widya*, 12(2), 107-118
- [10]. Abu, F., Gholami, H., Mat Saman, MZ, Zakuan, N., & Streimikiene, D. (2019). Application of lean manufacturing in the furniture industry: Study and analysis of motives, obstacles, challenges, and their application. *Journal of Net Production*, 234, 660–680.