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Assessing The Extent Of Cleaner Production Implementation In Industry In The Khartoum North Industrial Area, Sudan

Mohammed Amer Ahmed Mohammed1Almahdi Musa Attahir Musa[2]

[1]Bakht Alruda University, Faculty of Education, Department of Geography

[2]Bakht Alruda University, Faculty of Economics & Administrative Science

Department of Econometric & Social Statistics

Corresponding Author Email: mhdimusa@yahoo.com

Abstract

This study aimed to evaluate the extent to which cleaner production practices are implemented at two factories, Murooj Goods and Al-Muhandis Paints, located in the Bahri Industrial Area. The research problem was formulated in the following main question: To what extent are cleaner production practices implemented at Murooj Goods and Al-Muhandis Paints in the Bahri Industrial Area? The study was based on the following main hypothesis: There is awareness of the concept of cleaner production and its application among the manufacturers of Murooj Goods and Al-Muhandis Paints in the Bahri Industrial Area. The study used a descriptive-analytical approach. The results showed that Murooj Goods applies the concept of cleaner production at a rate of 87%, and Al-Muhandis Paints applies it at a rate of 67%. The Engineer's Paints factory applies it at a rate of 67%. Industrial and technological progress, coupled with the failure to choose appropriate technologies for waste management, has led to the depletion of primary natural resources, the emergence of occupational diseases and accidents, and pollution of the basic components of the environment. The study recommended implementing cleaner production practices in developed institutions and countries to achieve tremendous positive results in environmental conservation.

Keywords: Cleaner production, industry, Bahri Industrial Area, Sudan.

Introduction:

In recent decades, the world has witnessed a significant shift towards adopting sustainable development concepts that aim to achieve a balance between economic growth and environmental preservation. One of the most prominent modern strategies that has emerged to achieve this goal is the cleaner production strategy, this means optimizing resource utilization and minimizing waste and polluting emissions at various stages of production. In Sudan, the Bahri Industrial Area is a major industrial hub, housing numerous manufacturing, food processing, and chemical industries. However, the environmental challenges stemming from industrial expansion pose a growing threat to the urban environment and public health. The importance of studying the extent to which the principle of cleaner production is applied in this region comes as one of the effective solutions to address environmental issues and achieve sustainability. With rapid development, cleaner production technology has emerged, which is concerned with extracting products without harming the environment and depleting natural resources. Industrial and technological progress, coupled with the failure to select appropriate waste management technologies, has led to the accumulation of industrial waste and its

underutilization. This has resulted in the depletion of primary natural resources, the emergence of occupational diseases and accidents, and pollution of the environment's essential components. Due to this rapid industrial development, the term "cleaner production" has emerged, this is a modern technology that keeps pace with industrial progress and works to mitigate the environmental impacts that harm essential environmental components and human health. Governmental and private institutions—industrial and economic—must adopt cleaner production practices as a guiding principle to ensure their continued progress and development, prioritizing human health and the environment.

Study Problem:

Despite the growing global awareness of the importance of implementing cleaner production as a strategic option to reduce industrial pollution, many industrial facilities in Sudan still use traditional methods that have led to environmental degradation. From this standpoint, the study problem was formulated in the following main question:

To what extent is the cleaner production strategy implemented in the Bahri Industrial Area, Sudan? This leads to the following sub-questions:

1. What is the level of environmental awareness among workers and administrators in the Bahri Industrial Area?
2. What factors hinder the implementation of cleaner production in the Bahri Industrial Area?
3.To what extent does the Bahri Industrial Area adhere to local and international environmental standards**?**

Study hypotheses:

1. There is a weakness in the application of cleaner production principles in the factories of the Bahri Industrial Area.
2. There is a positive relationship between the level of environmental awareness among management and the degree of implementation of cleaner production.
3. The high cost of clean technologies is one of the most significant obstacles to adopting cleaner production.

Study Objectives: This study aims to achieve the following objectives:

1. To identify the extent to which cleaner production principles are applied in the Bahri Industrial Area.
2. To analyze the factors that hinder or encourage the application of cleaner production.
3. To assess the awareness of workers and managers regarding modern environmental concepts.
4.To present practical proposals for activating the application of cleaner production in Sudanese industrial facilities

Study Importance

The importance of this study lies in highlighting a vital environmental and industrial aspect that contributes to achieving sustainable development, and in providing scientific data that can benefit decision-makers in environmental and industrial sectors, and contribute to strengthening the concept of environmental responsibility among industrial establishments in Sudan.

Previous Studies

Qahham and Sharqraq (2016): This study aimed to identify cleaner production as a continuous improvement strategy in industrial processes and products, working to reduce the consumption of natural resources, pollution, and the amount of waste. The study reached several conclusions, the most important of which is that cleaner production is the best way to reduce pollution through a clear and simplified strategy and The study found that cleaner production using the (CLI/K) system was implemented through prior planning and independent research, at a cost that studies have shown will be recouped within a maximum of three years. The study recommended implementing this cleaner production strategy due to its significant economic and environmental benefits, achieved through describing, analyzing, and monitoring the product's lifecycle.

Saqr (2018): This study aimed to highlight the economic and environmental importance of investing in cleaner production technology in Syrian industry. It discusses the concept of cleaner industrial production and the means of achieving it, in addition to the economic and environmental benefits of applying this technology in Syria, and examines some experiences Successful in this field. The study reached the following conclusions: Implementing cleaner production technology in national industry is a necessary step towards adopting the environmental and economic dimensions in the manufacturing process. Cleaner production requires advanced technology The study aims to protect the environment, ensure economic and social profitability, and improve product quality by transforming it into an economically viable product with environmentally friendly

specifications. It recommended adopting cleaner production technologies in national industries due to the significant economic and environmental benefits they offer by reducing production and environmental costs.

Nasr and Nawal (2020): The study aimed to identify the reality of cleaner production in the Algerian economic institution by studying the problem of the extent to which cleaner production contributes to achieving sustainable development. In order to preserve the environment, economic institutions must adopt cleaner production techniques that would reduce costs on the one hand and improve environmental performance on the other. The study concluded that the Tebessa Cement Company has contributed to various initiatives in cleaner production aimed at reducing pollution from cement manufacturing. The study recommended introducing new technologies to its production methods to achieve environmental value in terms of natural resources and their utilization in a way that ensures future generations can benefit from them.

Hanan and Ali (2022): The study aimed to find out the possibility of including the environmental dimension in the various functions and activities of business organizations in light of the requirements of sustainable development, through adopting a cleaner production policy that limits the consumption of natural resources and reduces the risks to which humanity and the environment are exposed as a result of pollution. The study concluded that the cleaner production strategy is an important environmental strategy and deals with the source of the problem to achieve sustainable development and protect the environment.

Ali and Abdel Moneim (2023): This study aimed to raise awareness of the importance of the circular economy and cleaner production. The research problem focused on how to reduce negative environmental impacts and minimize waste and toxic gas emissions resulting from the expansion of metal products industries. The study assumed that following the principles of circular economy in the various stages of designing and manufacturing the metal product eliminates waste and contributes to reducing costs for both producers and users . The study followed a descriptive-analytical approach to examining samples of metal products and the extent to which they conform to rotary design and cleaner production strategies and considerations. The study reached several conclusions, most notably that, based on the nature of the raw material, metal products are long-lasting and recyclable, thus facilitating industrial enterprises specializing in its production adopt a circular economy model and create a closed, waste-free cycle, resulting in sustainable, environmentally friendly products. The environmental impact of the products is also determined in the early stages of the design process. The study recommended more support and guidance for Egyptian factories specializing in various fields of metal products to adopt the circular economy business model and its effective role in reducing costs and increasing economic growth.

The waste

The term "waste" refers to many different materials that are no longer useful, such as food scraps, paper, candy wrappers, chemicals, radioactive materials, motor oil, plastics, glass, metals, wood, and others. Therefore, it refers to materials left over from production processes or the outputs that have no value in the markets, and there are different classifications of them, which are medical, gaseous, liquid, radioactive and solid waste, which produce unpleasant odors due to the biological decomposition that occurs in them .It has also been defined as the collection of waste produced by domestic activities, and its recent significant increase is attributed to great population growth and improved living standards .In addition to economic prosperity, household waste is toxic, especially cleaning oils, paints, pesticides, batteries, and other similar materials. This waste requires special care in its disposal, as dumping it on the ground or in sewers poses enormous long-term risks, including various diseases for those exposed to it. [Further details have been provided. Research indicates that approximately twelve percent of household poisoning incidents resulted from household cleaning products, due to their inclusion of flammable and toxic substances, including bleaches such as toxic sodium hypochlorite, which causes lung damage, shortness of breath, and eye irritation, and detergents containing ammonia, which releases a toxic gas when mixed with bleaches.The term waste includes all types of garbage produced by the activities of all living organisms, including humans, animals, and others. Waste is classified as follows:

Waste classification: Industrial waste: This is the result of glass, metals, and wood, plastic, refuse, plastic, wood, metals, glass, ash, and broken utensils, and is classified into two sections: combustible waste and non-combustible waste.

Household waste: This is solid or semi-solid waste resulting from cleaning food, cooking, and other activities. It is divided into two categories: suitable as animal food, such as leftover food and vegetables, and unsuitable as animal food, such as eggshells.

Organic waste: This refers to materials that are susceptible to decomposition and are produced from food consumption and production. Therefore, they vary according to the months of the year, the customs and traditions of the population, and the geographical location.

Inorganic waste: This term refers to materials that are combustible, including plastics, wood, and paper, and other materials that are not combustible, such as metal sheets and glass.

Cleaner production strategy

Cleaner production strategy is actually one of the latest developments in environmental thinking over the last two decades. This strategy ranges from significantly reducing the consumption of environmental resources to avoiding the use of hazardous materials harmful to the environment, where possible, this involves improving the efficiency of product design and production methods to achieve these two goals, then reducing emissions, discharges, and waste during the production process and recycling waste, even to the point of considering the system of social values that gave rise to the demand for products or services, and trying to modify them to reduce luxury consumption, Wasting resources and harming the environment. Recently, cleaner production has become one of the most important environmental requirements that must be applied by economic sectors in all their industrial, agricultural and service fields. It is also considered one of the ideal options for managing the pollution problem in light of the rising costs of environmental management and the increasing interest in the environment. On the other hand Cleaner production applications include: Production processes: to conserve raw materials and energy, and to reduce the amount of all emissions, waste, and toxins, Products: to minimize the negative impacts of the product lifecycle, from raw material extraction to final disposal and Services: To consider the environment in the design and delivery of services.

Cleaner production strategies: There are several strategies for implementing cleaner production, including:

a) Improving the production process by eliminating operations that produce materials harmful to health or the environment.

b) Substituting materials: In many industries, there are ways to replace toxic materials with less harmful alternatives. Substitutions for health reasons include: Replacing certain solvents and compounds that can cause cancer with non-carcinogenic alternatives, including lead-based paints and coatings, and using safer alternatives, avoiding certain materials like asbestos fibers (fiberglass), using water-based detergents instead of organic solvent-based detergents, and using alternatives to ozone-depleting substances.

C) Upgrading or replacing equipment: The formation of pollutants can be countered by upgrading or replacing equipment, resulting in new technologies that are highly efficient in production and have a lower emissions of environmental pollutants.

d) Good internal management, which ensures that production systems operate optimally, adhering to specific internal practices and procedures such as: waste segregation, material leakage prevention, production scheduling, and good hygiene.

Objectives of Cleaner Production Technology

The overarching goal of implementing a cleaner production strategy is to work collaboratively to take measures that ensure sustainable development, meeting the needs of Arab societies and linking them to development plans while preserving the environment. This contributes to reducing the depletion of natural resources, increasing production, and saving on consumption, energy and water savings, improved product quality, and increased competitiveness are all benefits of cleaner production. It also contributes to reducing environmental protection costs associated with waste transportation, storage, and treatment, generates economic returns from recycling and reuse, and plays a crucial role in obligating companies to comply with environmental regulations legal specifications, improved working conditions, and benefits in occupational and environmental safety are all important considerations. Cleaner production is a means of technological development; more resource-efficient and less environmentally damaging production technologies have been developed, such as producing detergents and adhesives from plant sources instead of their conventional counterparts oil-based products that cause greenhouse gas emissions, the development of new dyes and paints instead of organic solvents, the use of alternative energy sources, and others.

Steps to Implement Cleaner Production Mechanisms:

a) Identify environmentally harmful activities and the maximum permissible limits of such harm under cleaner production mechanisms, while also identifying locations where these mechanisms could be successful.

b) Calculate the cost of implementing each opportunity individually and estimate the expected benefits resulting from the previously identified choices and alternatives.

c) Prioritize low-cost or zero-cost procedures, adopting specific implementation plans that clearly outline how to execute cleaner production steps in the easiest and most cost-effective way.
d) Provide financial and technical support, and adhere to a conscious management approach at all stages of the audits
e/ Providing the necessary information and making it available to the audit team continuously, so that they can prepare site plans, a list of required raw materials, detailed data on solid and liquid waste in terms of quantity, type and how to dispose of it, and maintain a record of the environmental condition, and another record of environmental health and safety.
h/ selecting the cleanest production team of highly qualified human elements to complete the guidance, organization, and review processes

Industry

Industry is defined as the process by which raw materials are transformed into a product or commodity that is offered in the market and consumed by humans in exchange for payment. There are several branches of industry. Since ancient times, we have known primitive industries, which rely primarily on manual labor, capabilities, and skills.
It is owned by humans, and there are still those who are passionate about working in this type of industry and still rely on it today as a source of income. It also has a consumer who goes to buy these products. As for the second type, it includes simple industries known by that name because they do not require huge capital and rely on local products available in the country .Furthermore, this industry is not transformed from one form to another. The most prominent examples of these industries are the preservation of vegetables and fruits for export from one country to another. The third and final type includes modern industries, which rely primarily on machinery, equipment, and capital .
The workforce has the ability to handle modern machinery, and with progress, there are a number of leading countries in that field, such as the United States of America, China, and Japan.

Cleaner production practices:

Cleaner production is based on a set of practices or choices adopted by organizations, factories, and companies to implement it. The literature in this field indicates that cleaner production practices include good operating practices, which are:
a) Management and Employee Practices: This includes employee training, incentives, rewards, and other programs that encourage the reduction of emissions and pollutants.
b) Storage and Handling Practices: This includes practices for handling incoming materials, appropriate storage conditions to minimize material damage and leakage, and their negative environmental impacts.
c) Practices for reducing pollutants and emissions resulting from advancements in machinery and equipment.
d) Waste segregation and sorting practices: These reduce the volume of hazardous waste by preventing the mixing of hazardous and non-hazardous waste.
e) Cost accounting practices: These include calculating the costs allocated to waste treatment and disposal.

Changes in raw materials: Changes in raw materials lead to cleaner production by reducing and eliminating hazardous and toxic materials that enter the production process, and thus reducing the emission of waste and pollutants. This is done by introducing fundamental changes that involve filtering and replacing materials.

Technology change: Refers to technological changes aimed at modifying machinery and equipment to reduce waste and pollutant emissions. These changes can range from simple modifications that can be implemented at low cost to process replacements that entail significant capital costs. Examples of such changes include:
A. Changes in the production process: Modification of equipment and the internal design of machinery and equipment.
B. Changes in the production process, such as flow rates, temperatures, and the working environment.
C. Product design changes: These are changes made to product characteristics with the aim of reducing waste emissions during production. Whether using the product or disposing of it after use, these changes can lead to redesigning the product and its technical composition in a way that reduces environmental impacts throughout the product's lifecycle. These changes are made through:
d) Changes in quality specifications.
e) Changes in product composition.
f) Product replacement.
g) Reduction, reuse, and recycling .

These terms refer to preventing the generation of waste at its source, starting with reducing the use of raw materials and energy and reusing the waste generated from them, to recycling it and making it into useful materials through a range of treatments, i.e., the repeated use of the product by changing its original use. Industry review for cleaner production: To identify options for cleaner production, an industry review for cleaner production is necessary to determine:

a) Environmentally harmful activities and their position relative to threshold limits.

b) Locations of cleaner production opportunities, including the cost of implementing each opportunity and an estimate of the benefits and savings.

c) Prioritization of cleaner production opportunities, giving precedence to low- or zero-cost measures with relatively short payback periods.

d) Develop an implementation plan outlining how to best implement cleaner production procedures in the factory.

Thus, an industrial audit for cleaner production can be defined as "the systematic review of chemical and physical processes to identify and highlight. "Opportunities to reduce waste and pollution, and improve the efficiency of these processes." A systematic approach to industrial auditing for cleaner production ensures the collection and evaluation of as much information as possible to identify opportunities for cleaner production that are financially, technically, and environmentally viable. The following are the steps necessary to conduct an industrial audit for cleaner production:

Obtaining basic information, clarifying chemical and physical operating processes, identifying inputs, defining outputs, establishing material and energy balances, references and standards, identifying possible options for cleaner production by defining clear development procedures, identifying hazardous and polluting wastes, and modifying

Some procedures or processes include calculating the costs and savings of cleaner production options through: technical feasibility studies, financial feasibility studies, prioritizing cleaner production options, developing an implementation plan for cleaner production, and executing the proposed cleaner production options.

Study Area

Khartoum North, known locally as Bahri, is a city located north of Khartoum, within the urban triangle that forms the Sudanese capital, alongside Khartoum to the south and Omdurman to the west. It is smaller than the other two .In terms of area and population, it is the most recent historically, but no less important, as it is one of the largest industrial areas in Sudan. It is also a vital link connecting the capital to northern Sudan via railway and to the south, as far as Kosti, and to South Sudan by Nile steamers. Khartoum North is a tranquil tourist destination, distinguished from other parts of the capital by its peaceful and pleasant atmosphere. It also plays a vital role in revitalizing Sufi activity through the shrines and domes of prominent Sufi figures in Sudan. As for Khartoum North itself, it encompasses a vast geographical area extending north to the villages and the Sabaloka Falls .

With the borders of the River Nile State along the Nile River, some of its most famous neighborhoods are Al-Sababi, Al-Shaabiya, Halfaya Al-Muluk, Al-Azirqab, Al-Darushab, Al-Amlak, Hallat Hamad, Hallat Khujali, Al-Danaqla, Shambat, Al-Kadru, Abu Halima, Al-Saroujiya, Al-Khujalab, Hallat Al-Faki Hashim, in addition to the villages of Al-Ja’aliyin, Al-Khalila, Al-Kabashi, and Al-Saqai.

The villages include Al-Tamaniyat, Al-Jili, O Si, Al-Wadi Al-Abyad, Wad Ramli, Al-Nakhila, (Al-Takina and Wad Atman), Dabak, Al-Salit, and (Qal'at Malik), in addition to the villages of the Qari area, namely (Al-Shayqiya, Al-Hawawit, and Al-Ghar). It is bordered to the east by the East Nile locality, which includes Al-Jeraif Sharq, Umm Dom, and Al-Haj Yusuf, and to the west by the Omdurman and Karari localities, from which it is separated by the Nile River.

Geographical Location, Area, and Climate:

Khartoum North is located between latitudes 8°–15° and 45°–16° North and longitudes 36°–31° and 25°–34° East. Its boundaries extend from the banks of the Blue Nile in the south to the Qari area on the border of River Nile State in the north, and it is bordered to the east by the Sharq locality .

The Nile at Qantara, and to the west, the course of the Nile River after the confluence of its two tributaries at Al-Muqran. Its area is 5,060 square kilometers, covering a quarter of the area of Khartoum State. The climate of Khartoum North is not significantly different from that of Omdurman or Khartoum, with temperatures ranging from 25°C to 40°C during the summer months from April to June.

Temperatures range between 20°C and 30°C from July to October, and between 15°C and 20°C during the winter months from November to March. Khartoum North has a population of approximately 1,184,000. The city has experienced significant population growth and demographic changes over the past few decades, resulting in a large influx of people .

The city is home to a diverse mix of Sudanese ethnicities who have migrated there and live in harmony with long-established communities such as Egyptian Copts, Armenians, and Greeks, who have adapted to Bahri's environment and integrated into its society. Most residents work in industry, services, and trade, with a significant portion employed in agriculture and transportation.

Administrative divisions: From an administrative standpoint, Khartoum Bahri is considered a locality within the Khartoum State. The Khartoum Bahri locality consists of three administrative units, each of which includes a number of residential neighborhoods and economic centers. These are: Bahri City Unit, which includes: Eastern, Western, the Grand Market, and Saad Qashra. Industries, Shambat, Al-Dunaqla neighborhood, transportation and petroleum. North Bahri Unit includes: the Central Market, Al-Kadru North, Al-Halfaya Al-Gharbiya, Al-Samrab Al-Sharqiya, Al-Darushab, and Tayba Al-Ahamda. Bahri Rural Unit: Al-Jili, Al-Salit, Al-Khujalab and the quarries

Agricultural activity in the region: Khartoum North has known agricultural activity for a long time, when the areas adjacent to the Blue Nile were fields and orchards. Agriculture still constitutes an important sector in it, as the agricultural area is estimated at about 1.8 million acres (2005-2006 season), of which only 700 acres were used. There are farms in Bahri for raising cattle and poultry.

Khartoum North Industrial Area: Located in the northeastern part of Khartoum North, the Bahri Industrial Area is bordered to the south by the Omar Al-Mukhtar neighborhood, to the north by the Tayba Al-Ahamda farms, to the east by the Kafouri area, and to the west by the Shambat, Al-Safiya, and Al-Mughtaribeen neighborhoods. The Bahri Industrial Area is considered one of the first industrial areas in the city.

It is one of the regions that witnessed the legalization of industrial investment and kept pace with the development of those laws and regulations. Industry in this region began a long time ago, specifically in the 1940s, and developed through the ages. In the 1950s, it focused on food industries, and in the 1960s...

The industrial area of Bahri was primarily characterized by textile manufacturing and grain milling. However, the 1970s and 1980s witnessed significant expansion and growth in many different industries. It can be said that an industrial boom occurred, particularly in the spinning and weaving industry, the production of wet and dry batteries, and blanket manufacturing. Furthermore, the 1990s saw the establishment of numerous pharmaceutical industries.

The end of the era witnessed the establishment of giant grain mills, and the Bahri Industrial Area is characterized by the following: it is considered one of the oldest and most established industrial areas in Sudan; it enjoys reasonable sanitation services; it possesses huge capital; it houses the largest grain mills in the country (Siga and Wita); it has a significant amount of infrastructure; it has the largest industrial capacity; and it contains factories not found in other industrial areas.

Examples include the White Nile Battery Factory (for dry cell batteries), the National Blanket Factory (for blankets), the Atlas Ceramics Factory (for ceramics), and the Polystyrene Plates Factory (for polystyrene plates).

Area of the Bahri Industrial Area:

The total area of the Bahri Industrial Area is approximately 4,767,488 square meters and the number of existing establishments is 1,022 (2003). The area consists of nine industrial blocks that vary in their area and the number of factories they contain.

Analytical Framework

Fifty forms were distributed to manufacturers in the Bahri Industrial Area: 30 to Marouj Factory and 20 to Al-Muhandis Paints Factory, proportionate to the number of employees in each factory. The forms were distributed within each factory using a random sample that included all job levels, from workers and administrators to quality engineers .

Safety and technical personnel, representing the research community, were selected to collect primary data for the scientific study. This data was intended to assess the application of cleaner production practices in Khartoum State factories, specifically focusing on the Bahri Industrial Area. The study also aimed to achieve its objectives of measuring factory owners' awareness of the cleaner production concept and identifying the extent to which this concept is implemented .

By understanding waste treatment and disposal methods, the questionnaire was divided into four sections (axes). The first section covered production, reflecting the extent to which factories have developed their production methods and kept pace with modernizations that reduce harm to the environment and human health. The second section focused on waste and its management, reflecting how factories deal with waste and their awareness of and application of the concept of cleaner production.

The third section examines the application of safety and security principles in the factory as a priority for protecting workers, the factory, and the product. The final section explores the relationship between worker health and the implementation of cleaner production practices. After data collection, descriptive analytical methods and statistical analysis were employed, utilizing percentage frequencies, which were then presented in graphs and charts.

The sample was taken from the Bahri Industrial Area, being the largest industrial area in Sudan, to measure the extent of cleaner production application in the industry. Two samples were taken from two different factories in terms of activity to illustrate the variation in how waste is dealt with and the extent of cleaner production application in the two factories.

Murooj Factory (Murooj Commodities Limited):

Murooj Factory specializes in food processing and food packaging. It is divided into Murooj 1 and Murooj 2. Murooj 1 specializes in sauces, ketchup, tahini, and mayonnaise, while Murooj 2 specializes in packaging and packing ready-made food items such as rice and lentils.

Powdered milk and sugar. The Marouj factory is located in the Bahri Industrial Area and employs numerous workers in various fields. The survey questions were answered by the production supervisor, who addressed all questions related to the four sections of the survey .

he production process at the Marouj factory is continuously updated to reflect advancements in manufacturing processes and maintain product quality. This includes the raw materials used in food products such as sauces, as well as the operating methods and the raw materials themselves. The factory holds two quality certifications: the first, awarded in 2018, is ISO 22000 Food Safety and Hygiene Management System (the latest version of the ISO standard).

The second is ISO 9001, which focuses on quality management systems. Murooj Factory has obtained ISO certification. Murooj Factory also prioritizes waste disposal, and the method of handling waste varies depending on its type, whether liquid or solid. Solid waste is usually sold or compressed for reuse, such as cardboard, while plastic is disposed of in landfills because it cannot be recycled.

It is recycled, and the waste is collected manually. The quantity is calculated per day after sorting, but there is no processing because the waste is disposed of or sold

Safety and Security Department: The Safety and Security Department is one of the departments managed by specialists at the Murooj factory. The factory is equipped with all safety devices and equipment, such as alarms, fire sensors, fire extinguishers, and earthquake sensors, as well as evacuation plans. Employees also wear a uniform that does not contain [unclear/missing information].

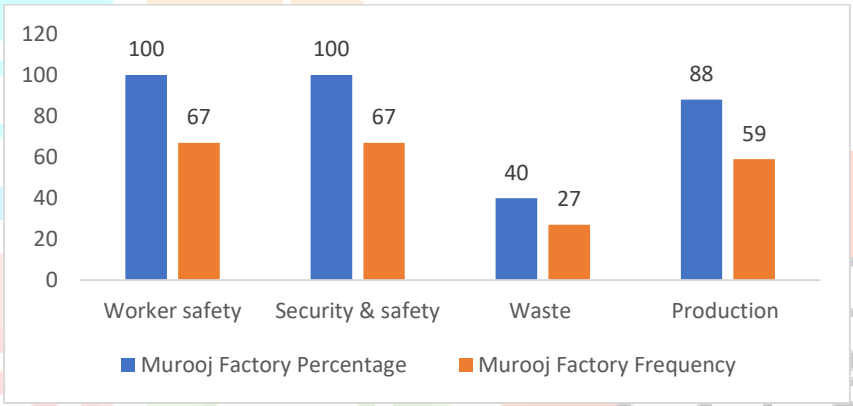
The garments have pockets or full wrists to prevent items from falling into the machines during production or clothing from entering them. Cleaning staff wear specialized clothing that identifies and protects them, including special protective footwear.

Occupational and Worker Safety Department: At the Marouj factory, the health of employees and workers is prioritized before employment by recording any cases in a medical file. Individuals with certain illnesses are prohibited from working due to the risk they pose to their own health, the safety of others, and the products themselves, such as incurable hepatitis. Regular medical checkups are conducted.

Table (1) Application of cleaner production standards in the four departments (Murooj Factory)

Factory Sections	Murooj Factory	
	Frequency	Percentage
Worker safety	67	100
Security & safety	67	100
Waste	27	40
Production	59	88

Figure (1) Percentage of application of cleaner production standards in the four departments (Murooj Factory)



Al-Muhandis Paints Factory:

A factory specializing in chemical industries, oil-based, decorative, industrial, and colorant paints. It has several distribution branches, with the main branch located in the Bahri Industrial Area. The factory handles production and manufacturing on-site, importing raw materials from abroad, but the packaging and manufacturing processes are carried out internally. The factory, where limestone is transported by truck and stored in the warehouse until the production of the current batch is ready.

Production Department: At the Engineer's Paints factory, raw materials are modified and processed to meet required specifications, and machinery is upgraded to the latest technology.

Machines are used to speed up the production process and obtain the best quality product. However, the production process itself is preferred because it is fixed, from the automated pouring of raw materials through pipes to the final product. All chemical processes and mixing take place within the factory in specific, well-equipped laboratories, where testing is conducted.

The product was tested after release to ensure its quality through random sampling and measurement. The research and development manager answered the questionnaire. The factory obtained ISO 9001 certification for its quality management system in 2015 and is currently working towards obtaining further certification through equipment upgrades .

Production, product development, and factory upgrades are all handled through internal auditing by a specialist. The Engineer's Paints factory employs specialists in each department, including a dedicated safety engineer.

Waste Management Department: At the Engineer's Paints factory, waste is handled daily, with the daily quantity calculated and sorted. The factory receives two types of waste: liquid and solid. Liquid waste is not disposed of but reused and recycled, such as chemical solutions. Solid waste, however, is treated by collecting and compressing them like cardboard, then redistributing or reusing them. Waste is collected manually by workers.

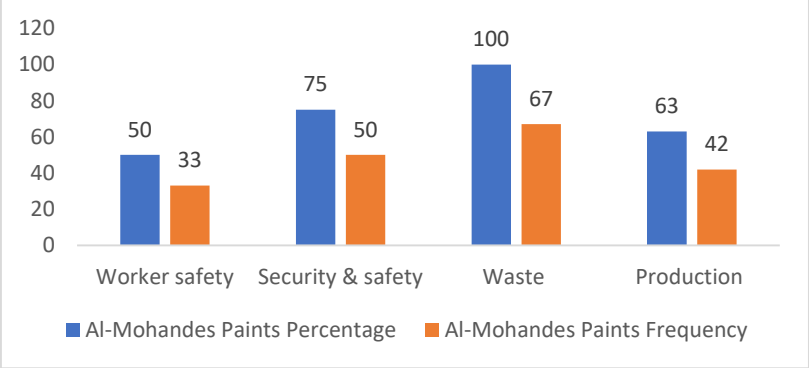
Safety and Security Department: Safety and security equipment is available in all departments and units of the factory, including fire extinguishers, which are placed at entrances. There are also fire alarms and various evacuation plans for all factory employees. Chemical laboratory workers wear appropriate protective clothing, such as goggles, gloves, and uniforms**.** The cleaning workers wear uniforms that distinguish them but do not protect them. Most of the workers who receive shipments do not adhere to the uniforms that protect them, such as face masks, gloves, and regular clothing.

The Occupational Safety and Health Department: Al-Muhandis Paints Factory prioritizes the health of its employees, providing them with medical insurance after employment, as well as regular checkups by the Ministry of Health to prevent serious and untreatable illnesses. The factory also has a health unit for treating and monitoring workers regularly, but this does not guarantee, the absence of illnesses such as allergies among workers who do not adhere to the dress code when receiving shipments from customers.

Table (2) Application of cleaner production standards in the four departments (Al-Muhandis Paints Factory)

Factory Sections	Al-Mohandes Paints	
	Frequency	Percentage
Worker safety	33	50
Security & safety	50	75
Waste	67	100
Production	42	63

Figure (2) Percentage of application of cleaner production standards in the four departments (Al-Muhandis Paints Factory)



Results:

1. Marouj Production Factory applies the cleaner economy strategy at a rate of 87%, while Al-Muhandis Paints Factory applies the cleaner production strategy at a rate of 67%.

2.The impact of implementing cleaner production is reflected in both factories in terms of quality management, product quality, worker safety, and consequently, the environment, as the percentages for the four departments in each factory were as follows:

3.In the production department of the Murooj factory, the cleaner production strategy was implemented at a rate of 88%, in the waste department of the Murooj factory at a rate of 40%, in the security and safety department of the Murooj factory at a rate of 100%, in the worker and employee safety department of the Murooj factory at a rate of 100%, in the production department of the Al-Muhandis Paints factory of 63%, in the waste department of the Engineer Paints factory by 100%, in the security and safety department of the

Engineer Paints factory by 75%, and in the safety of workers and employees department of the Engineer Paints factory by 50%. These percentages reflect the overall application of cleaner production.

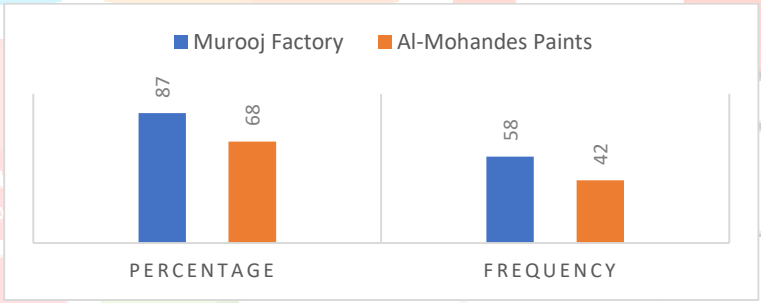
Discussion:

Given the importance of waste management, disposal, and treatment, as well as the need to modernize operating methods, production lines, and ensure worker and factory safety, the performance of all units related to cleaner production was assessed using a questionnaire administered at both factories . These percentages were found to reflect the extent to which these factories have adapted to new developments and implemented cleaner production practices. The results also showed that the Marouj factory is significantly more advanced in implementing cleaner production, not entirely, given the economic conditions and the delays in equipment adoption in Sudan. The Marouj factory could potentially , in the future, a significant leap forward is expected in the application of cleaner production concepts. It is noted that the Engineers Paints factory is initially performing well based on the results obtained, but it has the potential to fully implement cleaner production practices. Both factories currently lack automated equipment for waste management, rather than manual operation.

Table (3) Application of the cleaner production strategy in the two factories

Factory	Frequency	Percentage
Murooj Factory	58	87
Al-Mohandes Paints	42	68
Total	100	**150**

Figure (3) Application of the cleaner production strategy in the two factories



Can a cleaner production strategy be implemented in Sudanese factories as a whole? Yes, it can, especially after these results were presented and competition emerged to implement global standards in production and product quality. However, there are some shortcomings in the production process that take into account the product's environmental friendliness, particularly regarding product packaging, they adopt modern but not innovative methods that are environmentally friendly. Industrial progress in Sudan is going to a higher level, and the quality of Sudanese manufactured products can find a place in global markets. Manufacturers are keen to obtain quality certificates through their pursuit of continuous development and keeping up with the latest methods and best materials.

Recommendations:

1. Establish dedicated waste treatment and recycling units within the factory to make the waste reusable.

2. Implement automated waste collection systems instead of manual ones.

3.Develop or establish units dedicated to environmentally friendly product development.

4. Using new technologies and monitoring developments in cleaner production and applying them directly by activating mechanisms that allow for the application of developments.

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