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The Impact of Applying Environmental Activity-Based Costing on Cost Reduction: Applied Study in the Public Company for the Fertilizer Industry, Southern Fertilizers

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Abstract

The study aims to demonstrate how cost data technology contributes to environmental activity in low-cost settings. It is a rapidly evolving tool in the field of cost accounting and management accounting, identifying small activities and allocating small costs to those contributing to them, providing greater excellence in small costs. This technique is used in response to increasing environmental pollution and significant international and local pressures on small-scale issues. This approach helps identify areas of waste that are not available to business management, allowing for a relationship between economic performance and cost reduction. This can help identify opportunities to reduce costs, thus achieving the company's objectives.

Keywords: Cost Reduction, Environmental Activity Based Costing

Introduction

Cost reduction is a vital factor companies seek to achieve sustainable competitiveness in changing markets and increasing environmental demands. Organizations face growing challenges related to environmental pressures and stringent legislation, requiring them to improve resource efficiency and reduce waste, which leads to higher operating costs. In this context, environmental management accounting (EMA) emerges as a sophisticated system that contributes to accurately measuring and allocating environmental costs, helping management identify waste and redirect resources more effectively.

Environmental Activity-Based Costing (EABC) is an effective tool that allows companies to understand the relationship between various activities and their environmental costs by tracking the flow of materials, energy, and water within production processes. This system enables organizations to assess true environmental costs independently of traditional costs and reveals areas that require improvement to achieve significant reductions in environmental expenditures.

Furthermore, EABC provides accurate data that enables management to make informed decisions aimed at reducing waste, improving operational efficiency, and reducing harmful emissions, leading to lower costs of compliance with environmental laws and regulations.

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Through this strategy, companies can enhance their profitability without compromising environmental sustainability, a necessity in light of market and societal demands.

Accordingly, this study aims to evaluate the impact of implementing environmental activity-based costing (ABC) on reducing operational and environmental costs at the Southern General Company for Fertilizers. This study analyzes resource flows and identifies improvement opportunities that contribute to enhancing efficiency and reducing costs, serving the drive towards more sustainable production and increased profitability.

Research Problem

The research problem is summarized in how industrial companies face the challenges of measuring and analyzing the environmental costs of their various activities, especially in light of increasing environmental awareness and expanding global interest in sustainability. Companies face difficulty relying on traditional methods that integrate environmental costs into product costs without accurately isolating them, hindering management's ability to make informed decisions that contribute to reducing environmental impact and lowering costs. Therefore, the need has emerged to adopt an Environmental Activity-Based Costing (EABC) system, which allows for accurate allocation of environmental costs based on actual activities within the company. This system provides reliable information that supports sustainable strategies and contributes to reducing environmental costs associated with production. Accordingly, the research poses the main question: Does the application of Environmental Activity-Based Costing (EABC) contribute to reducing costs?

Significance of the Research

The research derives its importance from: 1) The importance of the research's contribution to improving the allocation of environmental costs across various activities in factories; 2) The research provides information on the environmental and financial impact of production activities, which helps management improve planning, control, and decision-making functions; 3) The research contributes to improving the optimal use of natural resources and reducing environmental waste by analyzing the efficiency of operational processes and determining the quantities and costs of waste, which helps reduce costs.

Research Objectives

The research aims to: Develop a model that demonstrates the potential of using the Environmental Activity-Based Costing (EABC) technique to reallocate environmental costs across various activities within the company, thereby reducing costs. Identify the ability of the Environmental Activity-Based Costing (EABC) technique to provide accurate information about the environmental impacts and identify waste sources for various activities within the company. Identify how management can leverage Environmental Activity-Based Costing (EABC) to improve the efficiency of operational activities and increase the effectiveness of environmental and economic performance within the company.

Research Hypothesis

The research is based on the hypothesis that:

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"Accurate monitoring of energy flow and consumption during the production process is an essential tool for identifying sources of waste and types of waste, which contributes to accurately allocating associated costs. This monitoring helps management make strategic decisions that improve environmental and economic performance, and provides opportunities to reduce costs and improve the efficiency of optimal resource utilization."

Research Sample Community

The research community is related to the industrial sector in Iraq, with the research sample represented by the General Company for Fertilizers Industry/Southern Region. The reason for choosing this sample is the nature of the company's work and its relationship with the environment. Its production relies on the consumption of air, water, and gas, in addition to the use of numerous chemicals in the production process.

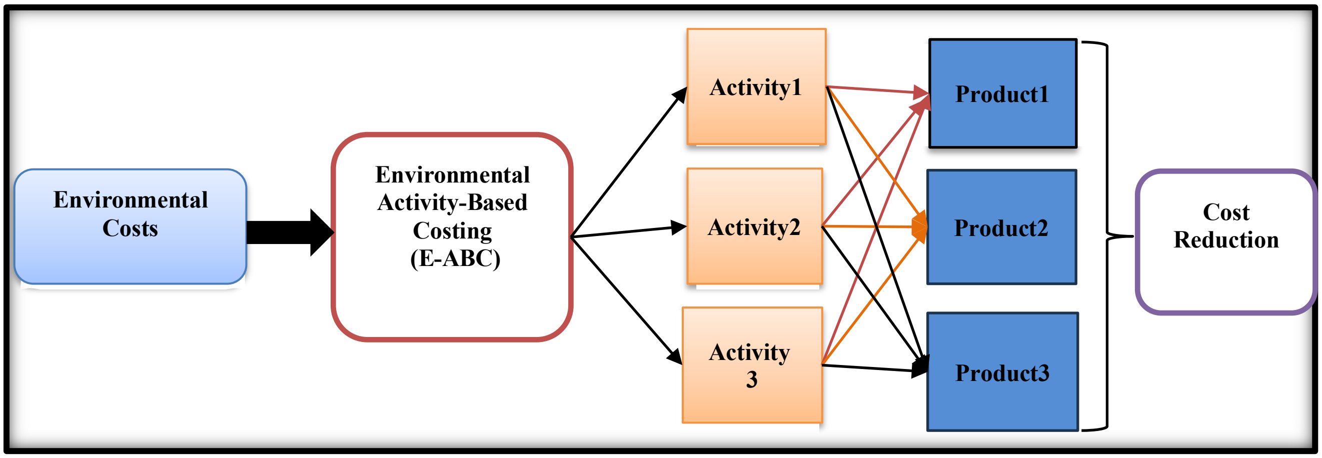

Figure 1. The Procedural Diagram of the Research

Previous

To complement the research methodology, a number of previous research contributions related to the research variables should be reviewed. These contributions contribute to outlining the structural framework for the research methodology. The researchers sought to leverage these studies to strengthen the theoretical framework and create the study model, as follows:

A study by Abbas Sabah Talib (2019) entitled "The Impact of Implementing an Activity-Based Costing System on Reducing Environmental Costs According to ISO 14001." The aim of this study is to demonstrate the impact of implementing an ABC system on reducing environmental accounting costs and improving environmental services in accordance with ISO 14001. This study also aims to achieve the goal of obtaining more accurate information for planning, control, and decision-making. The study concluded that implementing an activity-based costing (ABC) system helps reduce environmental costs, especially when appropriate environmental specifications such as ISO 14001 are adopted. The application of an activity-based costing (ABC) system is more equitable in distributing costs across products, based on the primary cause of cost generation, which is activities, and on several cost drivers based on the nature of each expense. These costs are then distributed across products based on other cost drivers, which assists management in decision-making. The study recommends promoting environmental awareness among

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employees through training courses and workshops. It is also recommended to establish a dedicated environmental accounting department to accurately identify and inventory environmental costs and improve emergency preparedness methods to reduce environmental impact

Research (Funda Yeni Özçelik, 2020) entitled "Integrating Activity-Based Costing with Environmental Management Accounting" aims to analyze the integration between the activity-based costing (ABC) system and environmental cost accounting to improve the allocation of environmental costs and accurately identify environmental impacts. This is aimed at supporting better management decision-making and reducing environmental costs through the application of this integration in the corporate environment. The research concluded that traditional environmental accounting systems conceal environmental costs and allocate them inaccurately, leading to incorrect management decisions. The study recommends the necessity of integrating the activity-based costing (ABC) system with environmental accounting, which will help allocate environmental costs more accurately, contributing to improved pricing, reducing environmental costs, and increasing managers' awareness, which leads to better sustainable decision-making.

Research (Ali Abdul-Hussein Hani Al-Zamili and Hussein Muhammad Harfil Al-Ajaimi, 2021) entitled "Activity-Based Environmental Costing Analysis and Its Role in Improving the Environmental Performance of Economic Units" aims to analyze environmental costs based on activities in the Kufa Cement Plant and study indicators. Performance and determining the extent of its use in reducing environmental costs. The study concluded that modern accounting techniques are not used to measure and analyze the environmental costs resulting from industrial activities. This leads to inaccurate calculations of environmental costs and the lack of an effective strategy to reduce these costs. One of the most important recommendations is to train workers and accountants at the Kufa Cement Factory on the use of modern accounting methods to separate and measure environmental costs based on activities, and to promote the use of performance indicators to improve environmental performance and reduce costs. It also encourages the separation of environmental costs from total costs to achieve greater transparency and effective resource management.

Research by Imad Abdul Sattar Al-Mashkour, Jaber Hussein Ali, and Majeed Musa Al-Kanani, 2023, titled "The Role of Green Activity-Based Costing in Achieving Sustainable Development." The aim of this research is to evaluate the impact of applying Green Activity-Based Costing (GABC) on sustainable development in manufacturing companies. The research concluded that GABC can be used to allocate indirect costs based on green activity and demonstrate how it impacts economic development and sustainability.

The current study's position in relation to previous studies

Previous studies reveal the following: All previous studies agree that the traditional costing system is incapable of accurately identifying and measuring environmental costs. Foreign studies have included identifying environmental costs using the traditional system, which requires significant effort and time, and is also costly. These environmental costs are integrated into the product cost and not identified separately, while hidden costs are not calculated. Previous Arab and foreign studies differ in their interpretation of environmental activities and environmental

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costs within environmental management accounting systems. Some researchers relied on identifying direct environmental activities and incorporating them into product costs using traditional systems, while others relied on the ABC system to accurately identify environmental activities. This discrepancy reflects the theoretical and practical gap in defining these concepts, necessitating further research and a thorough and comprehensive clarification of criteria to address both the environmental and economic dimensions.

The current study focused on the environmental activity-based costing technique, a development of the traditional activity-based costing system due to its focus on environmental issues. This study encompassed the cognitive and scientific foundations in terms of concept, reasons, objectives, and steps. It demonstrated how the cost is calculated based on the environmental activity of each product, with the goal of transforming the company's products into environmentally friendly products.

The current study also examined the impact of environmental activity-based costing in supporting sustainability by transforming products into environmentally sustainable products in accordance with environmental standards.

Therefore, the current study complements previous studies, working to build a model of the entire company, applicable to industrial companies, using applicable accounting methods and utilizing the resource flow technique using the more objective input-output method.

The Concept of Activity-Based Costing

With increasing competition in the manufacturing sector, including industries such as clothing, leather, pharmaceuticals, electronics, and cement, companies must provide unique customer service at reasonable prices. Many companies have been driven out of the market due to the difficulty of managing their high overheads. Consequently, companies need to reduce their operating expenses and use this as a competitive advantage to increase profits. Activity-based costing (ABC) was developed in the late 1980s to address the shortcomings of traditional accounting systems and keep pace with technological advances and automated manufacturing processes. (Al-Dhubaibi, 2021)

The components of an activity-based costing system are

An activity is defined by Data as (an event, task, or unit of work for a specific purpose) (Bhimani et al., 2023: 324). Activities are classified sequentially, as the activity-based costing system defines five activity levels: at the unit level, the batch level, the product level, the customer level, and the organizational support level. Most of these levels are not related to the volume of units produced. These levels are stated in: (Garrison et al., 2021: 306). Activities are also classified according to the value they add, including value-added activities and non-value-added activities (Hassani, Maaish, 2023: 45-46).

The activity cost pool: Activities in an organization are characterized by their diversity and large size, which necessitates their classification and regrouping into groups known as activity cost pools. This goal helps reduce the number of activities and simplify their directions. The activity cost pool serves as a "bowl" in which homogeneous costs related to a single activity measure are grouped within the activity-based costing system. (Horngren et al., 2023: 324)

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The activity measure is an allocation rule used in an activity-based costing system. It is also called the "cost driver" because the activity measure must "drive" the allocated costs. (Chhikara, 2020: 52) A cost driver is also defined as the activity that contributes the most to the cost of the activity. (Zamrud, Abu, 2020: 73).

Environmental Management Accounting

The concept of EMA is based on the need to support corporate environmental management with accounting information for several purposes, such as planning, decision-making, and control. (Gunarathne et al., 2021:3)

The information processed and utilized by EMA is of two main types: physical information related to resources and monetary information related to costs, revenues, savings, etc. Both types of information are equally useful for making effective decisions and improving environmental performance, as they enable the company to control its environmental costs, capitalize on benefits, and enhance environmental performance. (Phan et al., 2019:32) The effective implementation of environmental management accounting is considered an essential part of modern successful businesses because it enables the company to identify, synthesize, and evaluate various types of information to make final decisions. (Amir, 2020: 2) Environmental management accounting relies on the use of standard accounting techniques to identify, analyze, and manage environmental costs, with the goal of reducing environmental costs to the benefit of both the company and the environment, although in some cases the benefit may be to only one party. Environmental management accounting contributes to addressing these challenges by providing accurate financial and non-financial data that support decision-making that promotes sustainable development. Environmental management accounting is a newly developing concept, but it is gaining increasing attention from businesses and the academic community. This accounting offers an effective tool that goes beyond the traditional limitations of management accounting, by providing financial and non-financial data that supports managers in making strategic decisions (Antić et al., 2020: 56). It is defined as (an important management tool that provides executives with vital information related to the environment, enabling them to make more effective business decisions and enhance control over environmental pollution. (Huynh, 2024: 1).

Environmental Costs

Environmental cost accounting emerged in response to societal needs for social accounting reports that assess the extent to which organizations adhere to their social and financial responsibilities. This accounting and reporting are a relatively new phenomenon, plagued by the absence of mandatory laws and regulations. As a result, many organizations voluntarily submit social responsibility reports in their annual financial reports.

In traditional systems, environmental costs are incorporated into overhead accounts. These costs are not systematically tracked and are not attributed to the relevant operations or products. This leads to these costs being hidden in overhead accounts and being ignored by managers. Consequently, managers do not know the actual extent of these costs. This leads to inaccurate cost allocation and incorrect calculations of product costs. Mispricing also reduces a company's competitiveness. (Tsai et al., 2024: 4)

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Environmental cost accounting is a specialized branch of management accounting that focuses on analyzing and evaluating the costs associated with energy and water use, waste disposal, and sanitation. This discipline is characterized by addressing both financial and non-financial aspects, such as comparing the costs with the benefits of purchasing from suppliers that adhere to environmental standards, as well as assessing the potential impact on a company's reputation if environmental regulations are not complied with) (Zain et al., 2020: 724). Environmental cost accounting is considered a more comprehensive approach than management accounting, as it includes not only financial information but also physical information related to materials, energy, waste, and products. (Nguyen, 2019: 107) Environmental costs refer to the expenses incurred by economic units as a result of a deteriorating environment or the potential for such deterioration to occur (Derila & Dewi, 2020: 40).

Types of Environmental Costs (Ammamra, 2020, pp. 454-455)

Classification of costs by activities: 1) Detection activities: Product inspection and environmental audits; 2) Prevention activities: Preventing pollution before it occurs, such as supplier evaluation; 3) Preventive activities: Proactive environmental management and cleaner production projects; 4) Environmental failure activities: Internal (intracompany pollution and fines) and External (external environmental impacts (perceived and unperceived).

Classification of costs by product: 1) Productive activities: Use of raw materials; 2) Non-productive activities: Consumption of resources that become waste; 3) Waste control activities: Waste treatment and compliance with regulations; 4) Research and development activities: Developing innovative environmental solutions; 5) Intangible activities: Future commitments and the company's environmental reputation; 6) Cost Reduction: Industrial companies are seeking advanced management accounting methods to meet competitive market demands and avoid internal and external pressures. These companies aim to reduce costs without compromising product quality by optimally utilizing resources and energy and increasing the efficiency of production processes. The use of modern management accounting techniques, such as environmental accounting, helps reduce production costs and speed up operations compared to traditional methods. Therefore, cost reduction has become a key pillar for achieving a competitive advantage in challenging markets. (Saber, Al-Zibari, 2022: 272)

The importance of applying the activity-based costing system to reduce environmental costs according to the ISO 14001 quality standard.

Activity-Based Costing (ABC) is an advanced accounting method that contributes to improving cost management efficiency by linking costs to actual activities within the organization. This system is gaining increasing importance when applied within the framework of environmental regulations, particularly in accordance with the international environmental quality standard ISO 14001, which focuses on analyzing the environmental aspects of production activities and mitigating their negative impacts.

ABC helps identify sources of environmental waste and monitor non-value-added activities, enabling informed decisions to rationalize resource use, improve operational efficiency, and reduce waste and emissions. In this way, the system contributes to reducing environmental costs in a systematic manner based on accurate data. (Omar, 2023:14-18)

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Furthermore, implementing ISO 14001 enhances organizations' commitment to environmental responsibility by establishing an integrated framework for managing environmental aspects and associated risks. Obtaining certification to this standard also contributes to improving an organization's corporate image, increasing customer and investor confidence, and supporting its competitiveness in the market by complying with environmental requirements and achieving higher levels of efficiency and sustainability (Ahmed & Nouri, 2025: 504-510).

Practical Aspect

The State Company for Fertilizers Industry / Southern Region

Company Overview

The State Company for Fertilizers Industry / Southern Region is the first Iraqi company established in 1976 to produce urea fertilizer. It is located 3 kilometers from Khor Al-Zubair Port and approximately 35 kilometers from Umm Qasr Port. Khor Al-Zubair Port is the main port for exporting bagged and pelletized urea using advanced technologies.

The first plant produced granular urea with a modest capacity of 200 tons/day, in addition to sulfuric acid and ammonium sulfate. The second plant was established in 1973 with a design capacity of 420,000 tons/year of granulated urea. Construction was completed in 1976, and production began in 1977. Operation continued until 1980, during which time more than 950,000 tons of urea were produced.

During the Iran-Iraq War, the company's factories sustained significant damage, with the first project completely destroyed, and the urea plant in the second project also completely destroyed. The company is currently working to rehabilitate and develop the factories to reach their designed capacity by replacing some spare equipment and tools that impact production capacity, in phases. These efforts include the construction of two ammonia and urea production plants, each with a capacity of 1,000 tons/day of ammonia and 1,600 tons/day of urea. Another plant contains two production lines, each with a capacity of 1,000 tons/day of ammonia and 1,600 tons/day of urea, bringing the total production capacity of all the plants to 2,640,000 tons/year.

Determining and Allocating Environmental Waste and Costs

Analyzing Record Data and Identifying the Stages of the Production Process

The researchers focus on identifying and allocating waste costs for the ammonia plant through material and cash flow statements, and highlighting the importance of the extracted information in making most management decisions related to environmental and economic performance.

Analyzing Record Data and Identifying the Stages of the Production Process

It is important that the analysis be based on identifying the basic environmental efforts for measurements and analyses, analyzing environmental performance and performance indicators, and comparing alternatives to reduce the environmental impacts generated by the company by estimating the cost resulting from poor environmental performance.

There are extracts of various environmental factors, namely the company's consumption of

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purchasing, transportation, and waste management, which include many intertwined characteristics in the business environment accounting process. Therefore, material and energy flow information should be included within the environmental cost accounting process, through environmental management information, to achieve the integration of environmental costs with material and energy flow information, which is an integral component of corporate management.

The proposed model reclassifies environmental costs as follows:

Protection costs: These are costs related to activities aimed at reducing or avoiding environmental impacts resulting from the company's activities, with respect to the environmental present

Prevention costs: These include the costs of pollution prevention and remediation activities, environmental planning, environmental concerns, monitoring, and compliance with community and government requirements.

Compliance costs: These relate to the company's obligations to society, including activities resulting from legal regulations and systems, activities implemented by the company to comply with mandatory or voluntary environmental regulations, and the outputs of these measures that enable the reduction or prevention of the environmental impacts of the company's activities, whether related to services or products.

Environmental costs: These include the costs of wasted materials (including water and energy) and wasted labor.

Environmental Cost Classification

The term "environmental costs" is used to describe costs that fall outside the traditional scope of costing. This term often includes the outputs of industrial processes, such as wastewater, air emissions, industrial waste, and waste materials (solids), emissions, and environmental damage. The researchers divide the practical classification of waste costs into:

The first category

Environmental costs related to the inputs of industrial processes and the treatment of waste from environmental resources. This category includes, by sector, such as industrial waste treatment or changes in the composition of inputs, and includes the relationship between environmental technology and inputs.

The second category

Non-productive waste costs, which include materials wasted as a result of industrial processes. This also includes the calculation of the price of wasted materials (the value of wasted unproductive resources), energy, and water.

The third category

Indirect external environmental costs, which result from shared factors (such as mixed waste and industrial waste), are charged to non-productive outputs.

The fourth category

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It relates to the combination of non-productive outputs, such as waste and emissions (in addition to noise), which are collectively called environmental impact costs. This is the category that the current study addressed to measure. Practical Applications for Determining Environmental Costs in an Ammonia Plant:

This requires analyzing the stages of the production process and analyzing data from the records and statements of the General Company for Fertilizers Manufacturing/Southern Region, to display all information related to the quantities of materials used.

Determining the Stages of the Production Process:

Each stage requires knowledge of its inputs (raw materials, water, energy).

This is based on the standard quantities of inputs.

Determining the actual quantities of materials used.

Presenting the above information in tables for agreement.

Data from the raw material records and the Finance and Inventory Department records were used to determine material prices, as well as indirect cost records provided by the Studies and Planning Department, to calculate the associated environmental and financial costs. These stages are determined as follows: 1) Water Treatment Unit; 2) Cooling Tower Unit; 3) Power Unit; 4) Ammonia Plant; 5) Urea Fertilizer Plant

Determining the Inputs of Production Processes: The inputs for the production processes of the following units are determined:

Water Treatment Unit:

Water goes through several stages for treatment, and standard quantities are determined as follows: The first stage: involves receiving raw water from the Muhaila station located in Abu Al-Khaseeb The second stage: involves applying a preliminary treatment to the raw water to produce filtered water, a portion of which is sent to the cooling tower unit. The remaining portion is used in standard quantities of chemicals to complete the water filtration process, resulting in deionized water. These standard chemical inputs are as follows: aluminum sulfate 2.5 g/m^3 of water, polyelectrolyte 0.25 g/m^3 of water, and sodium hypochlorite 2 g/m^3 of water. The third stage: A standard amount of chemicals is added to the filtered water received from the first treatment to produce partially desalinated water (RO) during the second treatment. The standard chemical inputs are as follows: sodium hypochlorite 0.5 g/m3, sulfuric acid 50 g/m3, sodium hexaphosphate 10 g/m3, sodium sulfide 2 g/m3, and EDTA 600 kg. The combined stage: A standard amount of chemicals is added to the partially desalinated water (RO) received from the second treatment to produce deionized water during the third treatment. The quantities are as follows: sodium hydroxide 1 ton/cycle, sulfuric acid 1.25 tons/cycle.

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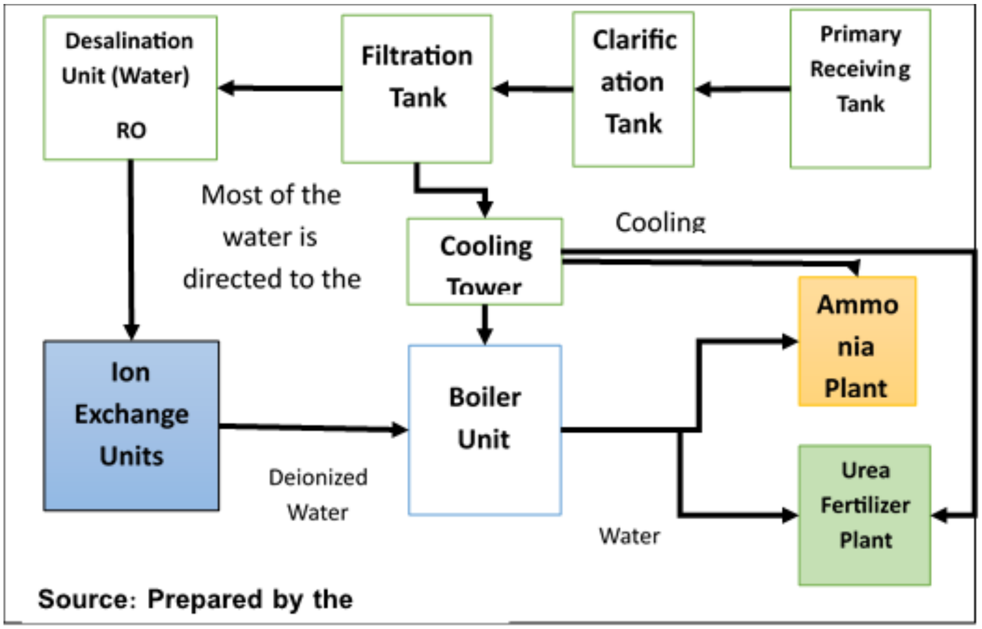

Figure 3. Water Flow Process from the Water Unit to Other Units

Cooling Unit: To cool the water in the cooling unit, we need the following standard inputs: 50 g/m³ sulfuric acid, 2 g/m³ chlorine gas, 400 liters of formalin, and 142.8 kW of electricity.

Power Unit: To produce one ton of water vapor, we need the following standard inputs: 1.044 kg hydrazine, 0.202 kg/m³ sulfuric acid, 1.1512 kg/m³ trisodium phosphate, and 841 m³ natural gas.

Ammonia Plant: The plant uses ammonia gas, carbon dioxide, and high-pressure water vapor. These materials are introduced into the reaction to produce urea fertilizer. The amount of steam consumed in the ammonia plant is calculated based on actual data from production sites and consumption rates. The standard inputs for each unit are determined as follows: combustion gas 315 m³/ton of ammonia, reaction gas 525 m³/ton of ammonia, and water vapor 2.4 tons/day. 1500 kWh of electricity = 36 kWh/ton

Urea Plant: To produce one ton of urea, the following standard inputs are required: 0.592 tons of ammonia, 0.775 tons of CO_2, 150 m3 of cooling water, 1.42 tons of steam, and 24 kWh of electricity.

Proposed model for determining waste and environmental costs

First: Material flow statement for the production process

This list aims to transparently monitor the movement of materials at each production stage and identify waste by comparing the standard quantities of inputs required to produce a specific quantity with the actual quantities actually used in production. The steps for preparing this list are: a) Obtain the standard quantities of inputs: These were extracted from the operating manual provided by the Japanese manufacturer, in collaboration with factory engineers; b) Obtain the actual production quantities: Through production reports, the planning department, and cost lists; c) Calculate the standard inputs for actual production: Divide the actual production quantities by the standard inputs; d) Compare the actual and standard quantities: If actual =

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standard (no waste)، if actual < standard (waste), if actual > standard (savings); e) Determine the amount of waste or saving for each material: Divide the actual inputs for each material by the standard inputs for the unit, then calculate the resulting difference in the actual production quantity.

Water Treatment Unit

Table 1. Water Waste Quantities for the Water Unit for the Year 2021

Month	EDTA	Chlorine Gas	Sodium Hydroxide	Sodium Hexametaphosphate	Trisodium Phosphate	Poly Electrolyte	Sodium Sulfide	Aluminum Sulfate
January	0.6	0	0.105372727	0	0	0.19933	0	31.9933
February	0	0	1.003413636	0	0	0.138545	0	29.88545
March	1.1	0	0	0	0	0	0	23.14495
April	0	0	0	0	0	0	0	31.074225
May	0	0	0	0	0	0.0741425	0	30.241425
June	0.175	0	0	0	0	0	0	26.116375
July	0.175	0	0.943303636	20	0	0.0294675	0	28.794675
August	0.25	4.5099	2.853795364	10.5	0.70198	0.0112575	0	27.712575
September	0.15	13.7623	1.481197545	0	0.66246	0.0347025	0.072492	29.247025
October	0.175	0	2.215924455	0	0	0.00867	0	28.0867
November	0.175	6.76245	0	0	0.65249	0	0.152498	27.945725
December	0.25	6.03295	3.223874955	0	0.90659	0.23925	0.151318	32.2925
Total	3.05	31.0676	10.82346868	30.5	2.92352	0.735365	0.376308	346.534925

We note that the amounts of waste are in sulfuric acid, chlorine gas, alum, sodium sulfite, sodium hexaphosphate, and sodium hydroxide, where the largest amount of waste is alum, which is equal to 346.534925, which is equivalent to (88.9%) of the amount of alum consumed, followed by waste in chlorine gas, which is equal to 10.82346868, representing (29%) of the amount of chlorine used, while sodium hexaphosphate is 2.92352 (20%) of the total amount consumed, and polyelectrolyte is 0.735365 (0.16%), followed by sodium hydroxide 30.5 (12%) of the total amount of soda consumed, followed by sodium sulfite 0.376308 (10%), and sulfuric acid 31.0676, representing (8%), where we find that the percentage of waste in alum is very large, which raises questions about how materials are dispensed and the accuracy of procedures Control and efficiency in the use of materials, and through interviews with engineers in the production departments, it became clear that the alum material is added manually due to a malfunction in the pump that adds the alum material, and that this material contains impurities and low purity, which affects the quantities used. This leads to the inability to add the standard quantities accurately, as purchasing a new pump will reduce the costs of wasting the alum material, which in turn leads to reducing costs and improving performance through the optimal use of materials with high efficiency. As for chlorine gas, it constitutes the second highest percentage of the waste quantities, and the reason for this is manual addition. As for the rest of the materials in which there is waste, the percentage is small. There is also an abundance in the consumption of some materials, which may have a positive or negative impact depending on the permissible limit.

Cooling tower Unit

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A material flow statement for the cooling tower unit will be prepared for the year 2021.

Table 2. Material flow statement for the cooling tower unit for the year 2021

Material	Quantity of cooling water	Stander Quantity	Production Standard Input	Input actual	Waste/Surplus Quantity in Production
Sulfuric Acid	7841512	50	392.0756	203	-189.0756
Chlorine Gas	7841512	2	15.683024	26	10.316976
Calcium Hypochlorite	7841512	0	0	25.42	0
Formalin	7841512	400	3136604800	0	0
Solid Dispersant	7841512	0	0	22.8	0
Biological Growth Dispersant	7841512	0	0	25	0
Corrosion Inhibitor	7841512	0	0	95	0
Electricity	7841512	142.8	1119767914	57246400	-1062522514

Boiler Unit

A material flow statement for the power unit will be prepared for the year 2021.

Table 3. Material flow statement for the power unit for the year 2021

Material	Product Quantity of stream	Stander Quantity	Production Standard Input	Input actual	Waste/Surplus Quantity in Production
Hydrazine	1839906	1.044	1920.86	5256	3335.14
Scale Inhibitor	1839906	0	0	3.5	0
Sulfuric Acid	1839906	0.202	372.04	330.15	-41.89
Trisodium Phosphate	1839906	1.1512	2118.441	4399	2280.559
Natural Gas	1839906	841	1547360946	143762821	-1403598125
Electricity	1839906	0	0	2077100	0

Ammonia Plant

A material flow statement of resources for the ammonia plant for each month of 2021

Table 4. Quantity of waste for the ammonia plant

Month	Steam		Electricity		Flue gas		Gas inlet	
	Ammonia2	Ammonia1	Ammonia2	Ammonia1	Ammonia2	Ammonia1	Ammonia2	Ammonia1
December	68658.2	0	728908	0	3237299	0	2360473	0
February	61849.4	0	10031190	0	3989961	0	3101360	0
March	53703.26	0	186408	0	2501170	0	2340190	0
April	58590.6	0	14244	0	4362155	0	5220507	0
May	67316.8	0	779192	0	3128733	0	3432742	0
June	67356.6	0	741944	0	546830	0	4173591	0
July	49344.6	0	564644	0	2856680	0	3532362	0
August	62841.4	0	482256	0	3407501	0	3997253	0
September	53364.6	0	653164	0	2693392	0	2876744	0

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October	63870.2	0	650388	0	3308657	0	3237649	0
November	62819.8	0	572052	0	2742399	0	2429554	0
December	67682.2	0	676528	0	2938373	0	2504259	0
Total	737397.7	0	16080918	0	35713150	0	39206684	0

From the material flow chart for the ammonia plant, the waste amounts can be observed as follows:

A- Regarding the combustion gas used in the ammonia plant, the research showed that the total waste in the combustion gas in ammonia2 = 35,713,150. The waste percentage in the combustion gas of the total amount of gas used is 16.8%. The environmental damage caused by the combustion process can be visualized, as the emissions and heat generated are among the major contributors to the ozone layer. B- Regarding the amount of water wasted in the form of steam, the total amount of steam wasted = 737,397.7, where the percentage of water wasted in the form of steam equals 65.97%.

C- Regarding the reaction gas, the study showed a clear waste in the reaction gas, which equals 39,206,684, where the percentage of waste in the reaction gas of the total amount of gas used is 18.5%.

D- Regarding the amount of electricity wasted in the ammonia plant, the amount wasted equals 16,080,918 kW, and the percentage of waste to the total energy consumed equals 73.2%.

By looking at the material flow statements for the months, we find that the company under study has a negative impact on the environment and climate through the large amounts of waste in each of the raw materials, energy and water, as each of them has a different impact on the environment or even on the economic system, whether when extracting or obtaining the raw materials, whether through waste and waste, or even in the form of energy, where it is possible to clearly imagine the resulting waste in energy and the accompanying waste in gas and air, as it is not offset by any benefit. This material model shows the reality of electricity consumption and what are the potential future environmental impacts and the amount of negative damage to the environment, as the list used to monitor the productivity of materials for each material during the production process in the ammonia plant, and by simply looking at the amounts of waste, the size of the loss in material productivity can be determined, as it shows that the outputs are less than the inputs because the inputs = actual products + the amounts of waste.

Second: Calculating the environmental costs

A list of calculating the environmental costs for the water unit as follows:

Table 5. Calculating the environmental costs for the water unit

Details	EDTA	Sulfuric Acid	Chlorine Gas	Sodium Hydroxide	Sodium Hexametaphosphate	Trisodium Phosphate	Poly Electrolyte	Sodium Sulfide	Aluminum Sulfate
Total Waste quantity	3.05	31.0676	10.82346868	30.5	2.92352	0	0.735365	0.376308	346.534925
Price per Unit	13365000	528000	1095600	1293600	5445000	0	13365000	5940000	792000
Total Environmental Costs	40,763,250	16,403,692.8	11,858,192.29	39,454,800	15,918,566.4	0	9,828,153.225	2,235,269.52	274,455,660.6

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Total	410,917,584.8

Total Environmental Costs=Total Waste quantity X Price per Unit

A list of environmental costs for the cooling tower unit for the year 2021, as follows:

Table 6. Environmental costs for the cooling tower unit for the year 2021

Material	Price per unit	Waste/Surplus Quantity in Production	Environmental cost
Sulfuric Acid	528000	0	0
Chlorine Gas	1095600	10.316976	11,303,278.91
Calcium Hypochlorite	0	0	0
Formalin	0	0	0
Solid Dispersant	0	0	0
Biological Growth Dispersant	0	0	0
Corrosion Inhibitor	0	0	0
Electricity	35500	0	0
Total			11,303,278.91

From the material flow and environmental costs list for the refrigeration unit, the following can be observed:

Regarding the chlorine gas used in the refrigeration unit, the research showed that the total amount of chlorine gas wasted is 10,316,976 tons. The environmental damage caused by emissions of this toxic gas can be imagined. The remaining materials, which are saved, may have a positive or negative impact on the production process, depending on the permitted usage. The environmental costs of chlorine gas are 11,420,534.4 tons, equivalent to 0.11% of the total refrigeration unit costs.

Environmental Cost Calculation List for the Boiler Unit

Environmental costs for the Boiler unit are calculated as follows

Table 7. Calculating Environmental Costs for the Boilers Unit for the Year 2021

Material	Price per unit	Waste/Surplus Quantity in Production	Environmental cost
Hydrazine	845000	3335.14	2,818,193,300
Scale Inhibitor	0	0	0
Sulfuric Acid	528000	0	0
Trisodium Phosphate	1750000	2280.559	3,990,978,250
Natural Gas	46000	0	0
Electricity	35500	0	0
Total			6,809,171,550

***Environmental costs = Waste quantity x Unit price**

From the material flow statement and the environmental costs statement for the power unit, the

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following can be noted: 1) Regarding the hydrazine used in the power unit to extract oxygen, the research showed that the total waste of hydrazine equals 3,335.14 tons; 2) As for the trisodium phosphate, the total waste equals 2,280.559 tons; 3) The remaining materials that are available may have a positive or negative impact on the production process, depending on the permitted usage; 4) The environmental costs of hydrazine are 2,818,193,300 dinars, equivalent to 28.3% of the total power unit costs; 5) The environmental costs of trisodium phosphate are 3,990,978,250 dinars, equivalent to 40% of the total boiler unit costs.

Environmental Cost Calculation List for the Ammonia Plant:

The purpose of preparing this list is to calculate the environmental costs of all raw materials, water, energy, gas, and other added expenses**:**

Table 8. Environmental Costs in the Ammonia Plant for the Year 2021

Details	**Waste Quantities**			
	Steam	**Electricity**	**Flue gas**	**Gas inlet**
Waste Quantities	725456	6569400	34166662	38678664
Price per unit	5411557	35500	21417.03	21417.03
Waste cost (environmental cost)	3,925,846,494,992	233,213,700,000	731,748,425,053.86	828,382,107,248
Total waste cost (environmental cost)	5,719,190,727,294			

Environmental costs of an ammonia plant = Waste quantity x Unit price

From the waste cost calculation lists (environmental costs), the following can be observed:

These costs represent hidden environmental costs, which are hidden within the product cost and are charged to the indirect manufacturing costs account. This has led to their concealment from management. Consequently, there is inaccuracy in calculating the cost of production due to the failure to optimally utilize available resources economically, which impacts the relevant company's decision-making. Waste in an ammonia plant includes waste within the plant itself, in addition to waste in other units that were wasted in the ammonia plant. This requires a reconsideration of the optimal use of resources for improvement, which helps rationalize relevant management decisions**.**

By identifying environmental costs, it is possible to identify the areas of waste and loss, and to determine the environmental and economic impact. This model demonstrates that the production costs in the ammonia department are inaccurate, as the costs of this unit have not been added to the costs of materials received from other units, which should be included in the cost of ammonia plant production. This model can be applied to all units where the percentage of waste is known to be high. Therefore, this model can provide a clear picture of the environmental and economic damage, and also provide accuracy in calculating plant costs.

The material flow statement helps establish a logical and control relationship between the quantities consumed in production and the surplus quantities sold in the local market. The produced ammonia must leave the production process either as a material consumed for urea production in the urea plant, or as a material sold or stored. The difference between the product

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and the inventory or sold is either consumed in production, sold, or wasted. Through personal interviews with engineers in the production department, the researchers discovered that a portion of the liquid ammonia evaporates into the atmosphere in the form of vapor due to exposure to high temperatures. This is extremely dangerous, requiring the re-liquefaction of this vapor using a liquefaction compressor and cooling, and then returning it to the ammonia tank. Therefore, this model offers a proposal to management regarding the choice between continuing to release ammonia vapor into the atmosphere and not utilizing it, in addition to the negative environmental impact, or purchasing a liquefaction compressor to utilize the vapor in the plant and reduce the negative environmental impact.

Furthermore, the waste of resources will impact the achievement of environmental sustainability, which is the fulfillment of the plant's needs. From natural resources without harming the share of future generations of resources, which will consequently affect the economic system of the environment. The total costs of other non-production departments in the company amounted to 89,519,170,652 dinars, which represents 85% of the company's total costs. The costs of production departments amounted to 15,711,582,255 dinars, which represents 15% of the company's total costs. The direct costs in the production process amounted to 1,0059,844,674 dinars, which is approximately 10% of the company's total costs. Therefore, the ratio of environmental costs to the company's total costs is equal to 14.7%. Therefore, this ratio can be used to determine the costs of waste in non-production departments, as the costs of waste in non-production departments equal 2,929,391,357 dinars.

Therefore, the company's total waste costs = 15,551,291,494.30 + 2,177,191,885 = 17,728,483,379.19 Iraqi dinars, representing approximately 17% of the company's total costs. Therefore, the use of resources must be reconsidered and waste and losses reduced**.**

Performance evaluation: By reviewing the company's technical report for 2021, the following became clear**:**

Product	Measurement Unit	Real Production	Planned Production	Ratio
Ammonia	Ton	163406	312000	52%

The model for calculating the costs of waste (environmental costs) indicated**:**

Product	Measurement Unit	Waste cost (environmental costs)	Real Production	Waste cost (environmental costs) per ton produced
Ammonia	Ton	17,728,483,379.19	238852	74,223.71753

Therefore, calculating the cost of waste per ton of urea produced led to the disappearance of the waste impact for the units that cause the greatest waste costs. Therefore, accurately identifying and allocating waste costs enables monitoring the environmental impact of each unit causing it. Thus, the research hypothesis was proven **:**(Accurate monitoring of the flow and consumption of materials, energy, and water during the production process is an essential tool for identifying sources of waste and types of waste, which contributes to accurately allocating associated costs. This monitoring helps management make strategic decisions that improve environmental and

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economic performance, and provides opportunities to reduce costs and improve the efficiency of optimal resource use).

By compiling material and financial information, management gains a complete picture of the environmental impact of the company's activities, as well as the relationship to economic performance, by achieving transparency in the flow of materials within the production process. This supports the proof of the main hypothesis**.**

Application technology environmental activity-based costing in company (EABC)

The system applied at the General Company for Fertilizers Manufacturing / Southern Region

The company relies on a production phase system to complete its production activity, which is urea fertilizer. These phases are as follows**:** A) Water treatment phase**;** b) Cooling unit phase; c) Power unit phase for steam production; d) Liquid ammonia and carbon dioxide production phase; e) The final phase, which is urea fertilizer production

Application technology environmental activity-based costing

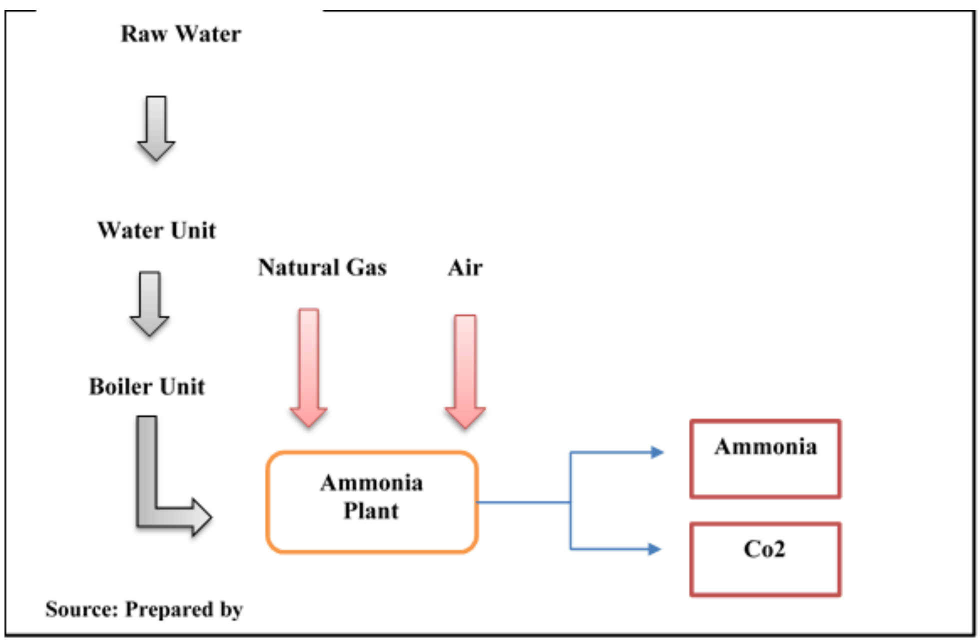

Figure3. illustrates the flow of the production process at the General Company for Fertilizers Manufacturing / Southern

After identifying environmental costs, the activity-based costing technique will be applied to the company's data under study, as follows:

Identifying Activities

By analyzing the company's various activities, studying the organizational structure and product flow within the company, and as far as environmental costs are concerned, the activities related to environmental costs were identified, which either contribute to environmental impact or address the environmental impacts of the company's economic activity. Identifying activities related to the consumption of environmental costs within the economic unit is an important step

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in analyzing environmental costs based on activities. These activities include: 1) Water treatment activity; 2) Cooling activity; 3) Steam production activity; 4) Liquid ammonia production activity; 5) Urea production activity as a final product

1- Determining the vector and the amount of the vector:

Table 9. Determining the cost vector and its amount

Type costs	Types activity	Drivers	Quantity driver	Ammonia product consumption from the wave
Supporting Activities	Water Treatment Unit	Quantity of Received Water m3	17332030	10528202.05
	Cooling Unit	Quantity of Cooling Water Consumed m3	7841512	4763263.327
	Boiler Unit	Quantity of Steam Produced (ton)	1839906	1117636
Primary Activities	Ammonia Plant	Quantity of Ammonia Produced (ton)	163406	6730
	Urea Plant	Quantity of Urea Produced (ton)	238852	0

Calculating the loading rate:

Table 10. Calculating the loading rate

Type costs	Types activity	Drivers	Quantity driver	Environmental costs	Rate
Supporting Activities	Water Treatment Unit	Quantity of Received Water m3	17332030	410,917,584.80	23.70856644
	Cooling Unit	Quantity of Cooling Water Consumed m3	7841512	11,303,278.91	1.441466762
	Boiler Unit	Quantity of Steam Produced (ton)	1839906	6,809,171,550	3700.825776
Primary Activities	Ammonia Plant	Quantity of Ammonia Produced (ton)	163406	5,719,190,727.24	34999.88206
	Urea Plant	Quantity of Urea Produced (ton)	238852	2,600,708,353.30	10888.3675

Water Treatment Unit= 410,917,584.80/17332030=23.7085664

Allocating indirect environmental costs to products:

Table 11. Allocating a portion of environmental costs to ammonia

Types costs	Categories Activity	Quantity Driver		Rate	Cost Production
		Urea	Ammonia		Ammonia
Supporting Activities	Water Treatment Unit	6803827.953	10528202.05	23.70856644	249,608,577.8
	Cooling Unit	3078248.673	4763263.327	1.441466762	6,866,085.7

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Primary Activities	Boiler Unit	722270	1117636	3700.825776	4,136,176,117
	Ammonia Plant	156676	6730	34,999.88206	235,549,206
	Urea Plant	238852	0	10,888.3675	0
Total					4,628,199,986.56

*Environmental cost per product = Load rate x Directed per activity

Collecting direct and indirect economic and environmental costs

Table 12. Shows the total costs, including environmental costs

Details	Ammonia
Direct costs	8,420,051,774
In Direct economic costs	37,310,056,845
In Direct Environmental costs	4,628,199,986.56
Total cost	50,358,308,606
Quantity of production	163,406
Total cost per unit	308,179.07

Source: Prepared by the Researcher

This table shows the total costs of ammonia production, including environmental costs, which equal (50,358,308,606). When environmental costs are excluded from the total costs, ammonia costs will decrease by the amount of environmental costs, as shown in Table (46):

Table 13. Total company costs after excluding environmental costs

Details	Ammonia
Direct costs	8420051774
In Direct costs economic	37,310,056,845
Total cost	45,730,108,619
Quantity of production	163406
Total cost per unit	279,855.75

Source: Prepared by the Researcher

Therefore, this comparison shows that identifying waste and losses and determining environmental costs enables the company to improve its performance and reduce costs in the ammonia plant from 308,000 per ton to 279,000, and in the urea fertilizer plant from 440,000 to 366,000, and increase its profitability by the amount of environmental costs (17,728,483,380.11) after excluding them and strengthening its position in the market. It also leads to a decrease in fines or their absence as a result of compliance with environmental laws. This is from the economic aspect. As for the environmental aspect, it encourages the company to optimally use resources according to a specified amount, which will reduce harmful emissions to the environment, which in turn works to support environmental sustainability in preserving natural resources and the share of future generations of those resources and avoiding their scarcity.

Prepper partial income statement

Table 14. shows the company's partial income statement to demonstrate the impact of the

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environmental cost allocation process on the level of product profitability**.**

Details	Ammonia
Sales price (1)	440,000
Total cost per unit (2)	279,855.75
profit (1-2) (3)	169,153.90
profit ratio (3/1)	36.3%

Source: Prepared by the Researcher

*profit ratio = profit / sales price 100%

From the table above, it can be seen that producers are profitable. By comparing the results extracted from the lists prepared according to the environmental activity-based costing system with the results extracted according to the traditional system, and determining the amount of reduction, we can observe the following**:**

We note that there is a difference between the two systems. In the traditional system, the cost of a single produced unit is high, as in the traditional system, environmental costs are hidden within indirect manufacturing costs. This has led to inaccurate costing of products, thus affecting management decisions. However, when applying the environmental activity-based costing system, we note that the cost of the product is reasonable, as the environmental costs have been accurately identified and the areas of waste and loss are known. This, in turn, makes it possible to reduce costs for products. When applying the activity-based costing technique, the environmental costs are allocated to the activities that cause these costs, and then the costs of each activity are distributed among the products, so that each product bears its actual environmental costs. The largest portion of the environmental costs is borne by the ammonia product, as most of the reactive processes, chemical use, and water use occur in the ammonia plant, while the urea plant has some processes for producing urea. This leads to accurate cost calculations, which in turn is reflected in decisions. Management optimizes the use of resources, which in turn reduces costs for the company. The overall profit margin reached 53.136% of the product's selling price. The reason for this increase in product profitability is the use of the ABC system, which charges each product for its actual consumption of environmental resources, whether directly or through the consumption of resources from auxiliary activities**.**

The ABC system contributed to the redistribution of production costs in a way that enables the company's management to determine the true cost of the product, including environmental costs. It also helped identify the variation in environmental resource consumption for each product individually, given the variation in activity direction. Providing this information will enable management to plan and monitor activities that cause environmental costs within the company. This all contributes to supporting environmental sustainability by conserving resources through the careful use of resources without waste, thus preserving the share of those resources for future generations**.**

Conclusion

The study concludes that Environmental Activity-Based Costing (EABC) is a modern management accounting tool that extends the concept of environmental accounting by enabling a more

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accurate and fair reallocation of indirect costs, including environmental costs, compared with traditional systems. EABC adds significant value to management accounting literature by offering a clearer and more detailed understanding of environmental activities due to its capacity for precise cost allocation. The study emphasizes that an environmental activity does not necessarily imply a completely pollution-free process but symbolizes efforts to minimize negative environmental impacts. Additionally, EABC supports cost reduction by redistributing indirect costs and providing management with reliable information that strengthens planning, policy formulation, and decision-making aimed at achieving integration between economic and environmental efficiency. The findings also demonstrate that information generated by EABC can be effectively used to evaluate companies' environmental performance using indicators of efficiency and effectiveness. The applied conclusions further reveal that the traditional accounting system used at the General Company for Fertilizers Industry in the Southern Region of Basra is inadequate in identifying, measuring, and disclosing environmental costs, as these are typically merged with indirect industrial costs. The existing accounting system is outdated and incompatible with modern industrial and environmental requirements. The results show that applying the EABC technique in the company enables accurate identification and measurement of environmental impact costs and determines product cost more precisely than the traditional system, ultimately reducing final product costs. The study also reports that indirect environmental costs reached 17,731,862,741.11 dinars, with ammonia production alone accounting for 4,628,199,986.56 dinars.

Recommendations

Based on these findings, the study recommends updating the costing system of the General Company for Fertilizers Manufacturing in the Southern Region of Basra to align it with modern industrial developments and to ensure the availability of accurate environmental information that aids management in making sound decisions. It is also recommended that new accounts be added to the accounting system manual to separately capture environmental costs using the EABC technique and to disclose these costs clearly in both internal and external reports. The company is encouraged to use information provided by the EABC technique to reduce environmental costs and minimize negative environmental impacts, alongside taking practical steps to reduce waste and pollutants while enhancing environmental efficiency. Finally, the study encourages researchers to expand on its findings through future research, particularly on topics such as integrating EABC with product life-cycle technologies to promote sustainable development and examining the role of EABC in managing environmental costs.

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