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Measuring Environmental Costs Using Modern Management Accounting Techniques and Their Impact on Improving Competitive Advantage: An Applied Study of a Cement Plant in Iraq

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Abstract: The proposed study attempts to quantify the environmental costs in a cement plant in Iraq and also to examine how the systematic identification and quantification of the environmental costs can be used to enhance the competitive advantage of the plant. The given research assumes the application of an applied case study methodology that includes two years of operations (2022 and 2023) and is based on environmental cost measurement instruments (material and energy flow tracking) and connects them with outputs, losses, and emissions during production. Measurement outcomes are then correlated to measurable competitive factors such as cost per ton, environmental cost per ton, waste ratio, power efficiency and environmental compliance. The information sources include accounting and production records and technical reports and is discussed through the trend analysis, benchmarking comparisons, and relationship analysis, provided that there is an adequate amount of quantitative data available.

The results show that the closure of the raw material mill precipitator contributes to high levels of environmental effects and other environmental expenses due to the presence of a number of shutdown hours per year. Though the proportion of the costs is relatively low in comparison with the total costs, these costs indicate an environmental gap that could be overcome and managed. The fact that there are no environmental fines and compensations due to environmental damages at the Badoush New Cement Plant means that the plant conforms to the environmental requirements and standards, thus giving it a competitive edge based on its reputation and willingness to do anything to protect the environment and the society.

The most significant of the study recommendations include that the plant management

must minimize waste, efficiency of resources and regulatory risks in a way that would improve its competitiveness, and must allocate resources towards afforestation and the green spaces of the areas surrounding the plant to help the production processes to reduce their harmful effects on the environment.

Key words: Environmental costs; modern management accounting techniques; competitive advantage; resource efficiency; waste; cement industry; case study.

Introduction:

The cement industry has been classified as one of the most resource-sensitive industries and also the most environmentally sensitive industry since it consumes energy and raw materials besides the emissions, dust, solid waste, and industrial wastewater. In a business setting where more and more environmental compliance pressures are pitted against price competitiveness pressures and product quality pressures, environmental costs are no longer marginal costs which can be ignored. Instead, they have now played a major role in the cost structure per ton, operational and investment choices, corporate image and market accessibility of firms without fines and market shutdowns.

It is in this light, that the study aims at offering an applied measure of the environmental costs at the Badoush New Cement Plant in the Governorate of Nineveh in the Republic of Iraq and also to examine how the results of such measure can be used to enhance the competitive advantage by reducing costs, improving resource efficiency, improving quality and minimizing risks. The research problem is in the fact that there is applied gap in cement plants at a point where the environmental costs are neither segregated in the accounting books and records nor are they precisely calculated or reported or distributed among the products and processes. They are instead normally solemnized into overall cost items (maintenance, services, energy, and miscellaneous expenses).

The purpose of the study is to recognize the ways of measuring environmental costs and also to examine how they affect the competitive advantage through the creation of quantitative indicators that can be used by the manager. It is also aimed at measuring annual environmental costs and determining the tendencies and operational origins and studying the correlation between the increase in environmental cost management and the increase in the indicators of competitive advantage. The importance of the study is based on facilitating management actions to increase the accuracy of the cost per ton by isolating the environmental costs and identifying the drivers of the costs, determining points of waste (materials, energy, water, and dust), and converting them into material cost-reduction opportunities, minimizing the risks of fines and shutdowns and contributing to the compliance, and improving corporate reputation and marketing capacity.

Previous Studies:

1. **Wang and Wang (2023)**, titled *"Research on the Competitive Strategy of the Cement Industry in the Period of the '14th Five-Year Plan': Taking Huaxin Cement Co., Ltd. as an Example."*

The study aimed to develop appropriate competitive strategies to enhance competitive advantages and achieve sustainable development. It sought to adopt Porter's Five Forces model to examine a representative firm in the cement industry Huaxin Cement Co., Ltd. and to analyze the company's competitive environment.

The analysis was taken in Huaxin Cement, which is among the manufactures of cement in China and was chosen to study its competitive advantages as compared to the other cement manufacturing plants.

The findings showed that there are a number of major findings, the first one being that a cost-following strategy, vertical integration strategy, and digital innovation strategy are comparatively the more suitable ones, and the cost leadership strategy is not. A good mix of the competitive strategies was identified to improve the competitiveness of the company and, therefore, facilitate sustainable development.

The research helped the existing research by offering information on the competitive strategies in the cement industry.

2. Bangura and Kargbo (2023), titled *"A Study on the Competitive Strategy of the Cement Manufacturing Business of Leocem Company in Sierra Leone."*

The research was intended to assess the competitive strategy of the cement manufacturing business of Leocem Company in Sierra Leone, determine the competitive strategies used by Leocem in the cement business and discuss the threats presented by the competitive environment in the cement industry.

The study was conducted on Leocem Cement Company in Sierra Leone, which was selected to analyze its competitive strategy.

The results showed that Leocem Company has employed various strategies in order to achieve a competitive edge in the cement industry. The strategies consisted of cost leadership, innovation focus, investment in research and development activities and use of latest technologies, investment in employee training and adoption of cost-flexible pricing strategy.

The research helped in advancing the current research because it offered a comprehension of competitive strategies in cement manufacturing businesses.

3. Hazrati et al. (2022), titled *"Measuring Environmental Costs and Quality Costs and Their Role in Improving Product Quality and Achieving Customer Satisfaction."*

The study aimed to examine the available methods and approaches for measuring and disclosing environmental costs, as well as to clarify the concept of quality, its dimensions, and customer satisfaction.

It was found that the focus of management on environmental cost measures and information by the management assists in creating good relationships with internal and external stakeholders. Environmental cost measurements also help companies to accomplish the quality of production as well as the environmental costs information aids the management to make rational decisions about whether to make or to buy.

This study contributed to the current research by providing insights into the available methods and approaches for measuring environmental costs.

4. Merhej et al. (2020), titled *"Environmental Costs and Their Role in Measuring and Improving the Environmental Status of Industrial Companies: An Applied Study in the South Cement Factory – Al-Muthanna Governorate."*

The study aimed to identify the most appropriate methods and approaches for measuring environmental pollution costs in order to determine environmental responsibility, as well as to emphasize attention to the environmental impacts caused by industrial companies as a result of their industrial activities.

The research was carried out on the industrial firms namely the South Cement Factory under the Al-Muthanna Governorate, Republic of Iraq that is one of the firms attached under the Iraqi

Ministry of Industry and Minerals. This was done to quantify the environmental cost so as to have an environmental responsibility strategy directed to environmental protection.

Results indicated that environmental processes and operations were not so much optional but mandatory because the majority of the activities were performed by the management of the plant to adhere to the binding environmental laws that applied to the Southern general Cement Company. The Environmental Unit, Inspection and Engineering Inspection Departments, the Precipitators Department, the Occupational Safety and Health Department and the Research and Development Department were considered to be among the most conspicuous technical administrative units to work on the environmental protection. The research also identified lack of environmental awareness in the company laboratory in terms of its contribution to the environment and little focus on the social welfare issues given that the factory was more concerned with the productivity and profitability. As it is viewed by the company, this concentration was viewed as a sign of efficiency without properly taking into account the environmental impacts of its operations. This scenario brings about the necessity to come up with environmental performance indicators which can help in the measurement of the costs of environmental activities.

This study is relevant to the existing research as it appears to offer insights into the costs of the environment and their application in the quantification and enhancement of the environmental state of the South Cement Factory in the Al-Muthanna Governorate.

Distinctive Features of the Current Study Compared with Previous Studies:

The difference between the present research and the past one is that contemporary management accounting methods are used to quantify environmental costs which are Material Flow Accounting (MF), Product Life Cycle Costing (PLCC), and benchmarking, and analyze the influence that they have on enhancing competitive advantage. The study also determines the cost of the environment caused by closing of the electrostatic precipitator of the mills of the raw materials used in the cement plant.

Concept of Environmental Costs:

Environmental costs have a number of definitions. This paper discusses some of those definitions. Environmental costs have been described as those expenses that are incurred by a company due to the utilization of technologies with negative effects on the environment and the expenses in treating damages and other negative effects that the company was not able to prevent or control. They are also a collection of principles that furnish critical information on the environmental management activities (Bicer & Eldarewi, 2019, p. 208).

The environmental cost has also been defined as the cost that is incurred in monetary terms in order to prevent and minimise environmental impact, and the cost of remediation and elimination once the damage has been caused. It is associated with any expenses devoted to the prevention, reduction, or avoidance of environmental effect, removal of the environmental effect and implementation of the restoration measures in case of a disaster, as well as other related actions (Solomon & Ayodeji, 2019, p. 60).

Benefits of Voluntary Investments in Environmental Costs:

Voluntary investments in environmental costs often yield financial benefits through the following aspects (Hassan & Onsiro, 2024): reducing expenses associated with pollution, enhancing efficiency, lowering environmental costs, and mitigating future liabilities.

Going by the foregoing, it can be noted that voluntary investments provide financial gains to firms based on the strategic plans that they assume to limit the damaging environmental effects caused by their production operations and to strive to minimize the environmental expenses.

Characteristics of Environmental Costs:

Environmental costs (EC) have several distinguishing characteristics, as identified by Yan (2014):

- **Hysteresis:** Environmental costs do not appear immediately like production materials; however, their accumulation may inevitably lead to environmental damage once they transform into qualitative change.
- **Continuity:** The measurement of environmental costs is characterized by continuity, as environmental costs should be measured not only during the production or sales process but throughout the entire product life cycle.
- **Potentiality:** The impact of current corporate activities on the environment may not be immediately apparent in parallel with ongoing economic activity; rather, it may emerge gradually over time, reflecting the specific nature of environmental activities.

Classification of Environmental Costs:

Environmental costs can be classified into four main categories (Basuki & Irwanda, 2018):

- **Prevention Costs:** They are prevention activities like supplier evaluation and selection, tool evaluation and selection, process and product design, environmental studies, the development of the environmental management system, environmental risk audit, ISO 14001 certification and product recycling.
- **Detection Costs:** Detection activities consist of auditing environmental activities, inspection of process and product, creation of environmental performance measures, testing and measurement of pollution levels, and checking of suppliers performance over the environment.
- **Internal Failure Costs:** Internal failure activities entail the operation of pollution prevention equipment within the company, waste management, operation of environmental policy equipment that the company has adopted in protecting the environment, waste generation licenses, and recycling of remaining production waste.
- **External Failure Costs:** External failure activities include cleaning contaminated water and remediating soil affected by oil spills.

Following the above, it may be noted that categorizing the environmental costs in terms of prevention costs, detection costs, internal failure costs, and external failure costs may be used to enhance the management of resources as well as minimize the environmental impact, which will, in turn, enhance the sustainability and will reduce the long-term costs.

Innovative Approaches in Environmental Costing:

The innovative methods of environmental costing incorporate the following (Ayinla et al., 2024): integration of environmental consideration in business activity, environmental considerations in decision-making, and environmental processes in the financial reporting.

It could be observed that the implementation of new methods in environmental costing will increase the efficiency of performance and effectiveness of the company in terms of adherence to environmental responsibility, which will help it to realize sustainable competitive advantage.

Sections of Environmental Costs:

Environmental costs are divided into two main sections (Pei, 2017):

- **Internal Environmental Costs:** These are expenses due to the internal factors of production of the organization and are quantifiable in monetary terms. These are the environmental prevention costs and the cost of pollution emissions of the production process.

- **External Environmental Costs:** These are those costs that are incurred on production activities which have a harmful effect on the environment and are not incurred by the company as part of its accounting system. As far as sustainable development is concerned, though, the companies must bear these costs in order to safeguard environment and environmental justice. They comprise the cost of extracting the resources and the cost of disposing the pollution.

In the light of the above, it is possible to note that categorizing the environmental costs into the internal and the external ones also indicate the significance of businesses being accountable to their environmental effects. It also helps in adoption of more comprehensive accounting systems in order to attain sustainable development, which, in its turn, leads to competitive advantage.

Concept of Competitive Advantage:

There are several definitions of competitive advantage (CA). One definition describes it as "the superiority in creating products or services that competitors cannot easily imitate, enabling market share acquisition and long-term profits" (Rusdianto et al., 2018, p. 203). Another defines competitive advantage as "a specific positive attribute possessed by an entity, in which it excels and differentiates itself positively from its competitors" (Yuleva, 2019, p. 73).

Characteristics of Competitive Advantage:

The essential characteristics that technology must possess to achieve competitive advantage can be summarized as follows (Saura et al., 2022):

- Attractiveness: The market and industry should be favorable to the opportunity, which makes products and services more attractive in the eyes of the marketing.
- Verifiability: It must be practically verifiable, that is, it must have enough resources to implement the technological features in the company products and services.
- Sustainability: The opportunity must be long term and not just the short term or medium term because the success of this opportunity may create opportunities in future.
- Value Creation: The opportunity must be a profitable one that is oriented at the improvement or enhancement of the features of the existing products that reinforced the margins and made possible the greater prices of the products with references to the consequent improvements.

On the above, it may be noted that establishing competitive advantage (CA) does not only depend on the adoption of technology, but also on its market appeal, practical implementability available resources, long term sustainability as well as the capability of creating real value that improve the company position in the market.

Dimensions of Competitive Advantage:

There are five dimensions of competitive advantage (CA) as follows (ALShanti et al., 2025):

- ✓ **CR:** Cost Reduction
- ✓ **QI:** Quality Improvement
- ✓ **TE:** Time Efficiency
- ✓ **OR:** Operational Reliability
- ✓ **INN:** Innovation

Organizations are also under no end pressure to evolve their environmental performance as they strive to meet economic and social objectives and this is in a combined way of increasing their competitive advantage (CA) (ALShanti et al., 2025). Well-performing companies in terms of their environmental performance and reputation are more competitive and environmentally friendly

consumers would rather buy the products and services with the help of eco-friendly processes (Ifada & Jaffar, 2023).

As it is possible to observe, the five dimensions of the competitive advantage (CA) can be seen as the key foundations of greater organizational flexibility to rising demands, especially in the context of prioritizing the ecological performance over the economic and societal goals. This helps in attaining sustainable competitive advantage, and environmental aspect plays a crucial role as it increases customer awareness on environmentally friendly products, which are not harmful to the environment.

Methods of Achieving Competitive Advantage:

There are several ways of obtaining competitive advantages (CA), including presenting unique products or services, offering products or services at the most reasonable price, and targeting certain market segments (SADALIA et al., 2021). Businesses need a variety of strategies in order to gain competitive advantages (CA) and also to establish high positions that can be defended in the context of industrial competition forces.

As it can be noted, these strategies are vital; however, their success will be determined by the market situation and the resources available. This is why firms need to be flexible in their choice and follow these strategies depending on the market conditions and needs.

Indicators for Evaluating Competitive Advantage:

The competitive advantage (CA) may be measured by a number of indicators that are crucial to assessing the competitive position of the company. These are innovation, resource attributes, product features, operational capabilities, financial metrics and market metrics (Gitonga et al., 2025).

As it could be observed, competitive advantage (CA) is based on an interconnected cluster of indicators, and each factor is the key to the ability of the company to withstand competition and make it stronger in the market.

Obstacles to Achieving Competitive Advantage:

Commercial companies face several challenges that hinder their ability to achieve a strong competitive advantage (CA). The most prominent of these challenges include (Alsada & Kumar, 2021):

- ✓ Inadequate assessment of opportunities and inability to anticipate potential environmental risks.
- ✓ Inefficiency in operational processes and failure to achieve optimal performance.
- ✓ Limited managerial authority and lack of decision-making autonomy.
- ✓ Declining human resource efficiency and weak administrative communication channels.
- ✓ Lack of databases and absence of an effective management information system.

Using the above, we can note that weak organizational structures, reduced human resource efficiency, and the lack of effective information and management systems are all issues that hamper competitive advantage (CA) within industrial companies. This highlights the importance of building a conducive organizational culture and boost managerial independence towards the best performance.

Price and Competitive Advantage:

Competition drives price reduction, increases sales, and enhances profitability. The characteristics of price leadership are as follows (Pasholikov, 2024):

- Predatory Pricing: Using lower prices than the cost to realize future profits or to secure a competitive advantage not possible by other competitors in the market.

Price Competition: This can be done where price is one of the determinants of purchase.

- Financial Capacity: Price rivalry can occur when the company is capable of having enough financial resources.
- Cost Reduction Strategy: This is applied by the company after it has made huge cost savings and low production cost and reduces the price of the product in a manner that competitors will not be in a position to maintain the same price.

According to the foregoing, it is possible to note that price is a crucial part of competitive advantage. A firm can lower its product prices without compromising quality and cost-effectiveness to make lower returns, stay in the market without its rivals, and not affect its financial status in a detrimental way, taking advantage of its financial strength to affect the actions of competitors in the market.

Practical Aspect of the Study:

In this part, the environmental costs are quantified through the contemporary management accounting (Material Flow Accounting and Product Life Cycle Costing) by monitoring the flow of materials at every cycle of the product life cycle. The variation between the overall input and the output is waste. Environmental costs in the product life cycle are calculated using abnormal waste which is the worst to the environment.

The study sample was the Badoush New Cement Plant in Nineveh Governorate Republic of Iraq. Analysis of material flow was done throughout the product life cycle and benchmarking was done on the same plant based on the financial data of two years and this provided the results of the study.

1. Research, Development, and Design Stage:

Table (1) presents the measurement of environmental costs for the research and development stage at the Badoush New Cement Plant. The environmental costs due to abnormal waste in 2022 amounted to **3,543,752 IQD**, which was higher than in 2023, where the cost was **2,894,688 IQD**.

Table 1: Environmental Costs for the Research, Development, and Design Stage at Badoush New Cement Plant for 2022 / 2023

Details / Research, Development, and Design Waste	**Raw Materials / Ton**		**Notes**
	2022	**2023**	
Inputs	8,103	8,927	
Outputs	5,085	5,650	
Waste	3,018	3,277	
80% Abnormal Waste	2,414	2,622	
Total Plant Costs	6,177,764,443	5,160,448,083	
Production Quantity	126,234	140,260	
3% of Cost per Ton	1,468	1,104	
Environmental Costs of Lost Materials / IQD	3,543,752	2,894,688	

Table Prepared by the Researcher Based on the Plant's Financial Data

2. Quarries and Crusher Stage:

In this stage, Table (2) shows the environmental costs for the quarries and crusher stage. The highest environmental costs were recorded in 2022, amounting to **55,534,665 IQD**, while the environmental costs in 2023 were lower, totaling **46,399,280 IQD**.

Table 2: Environmental Costs from Quarries and Crusher Waste at Badoush New Cement Plant for 2022 / 2023

Details / Quarries and Crusher Waste	Raw Materials / Ton		Notes
	2022	2023	
Quantity of Stone Entering Production	292,454	324,949	
Outputs from the Process	264,085	293,428	
Waste	28,369	31,521	
80% Abnormal Waste	22,695	25,217	
Total Plant Costs	6,177,764,443	5,160,448,083	
Production Quantity	126,234	140,260	
5% of Cost per Ton	2,447	1,840	
Environmental Costs of Lost Materials / IQD	55,534,665	46,399,280	

Table Prepared by the Researcher Based on the Plant's Financial Data

3. Raw Material Mills Stage:

From Table (3) below, the environmental costs for the raw material mills stage reached their highest amount in 2022, totaling **438,600,280 IQD**, while the environmental costs were lower in 2023, amounting to **366,347,462 IQD**.

Table 3: Environmental Costs from Waste in the Raw Material Mills Stage at Badoush New Cement Plant for 2022 / 2023

Details / Waste in the Raw Material Mills Stage	Raw Materials / Ton		Notes
	2022	2023	
Quantity of Materials Entering	267,568	297,298	
Outputs from the Process	118,201	131,334	
Waste	149,367	165,964	
60% Abnormal Waste	89,620	99,578	
Total Plant Costs	6,177,764,443	5,160,448,083	
Production Quantity	126,234	140,260	
10% of Cost per Ton	4,894	3,679	
Environmental Costs of Lost Materials / IQD	438,600,280	366,347,462	

Table Prepared by the Researcher Based on the Plant's Financial Data

Environmental Costs Due to Shutdown of Electrostatic Precipitator in Raw Material Mills:

Table (4) shows the environmental costs resulting from the downtime hours of the electrostatic precipitator in the raw material mills. The highest environmental costs due to the shutdown occurred in 2022, totaling **5,951,104 IQD**, while in 2023, the environmental costs were lower, amounting to **3,837,187 IQD**.

Table 4: Environmental Costs Resulting from Downtime Hours of Electrostatic Precipitators in Raw Material Mills at Badoush New Cement Plant for 2022 / 2023

Details	Years		Notes
	2022	2023	
Quantity of Materials Entering	267,568	297,298	
Operating Hours of Badova Raw Material Mill	2,620	2,257	
Operating Hours of Badova Mill Electrostatic Precipitator	1,406	965	
Downtime Hours of Badova Precipitator	1,214	1,292	
Operating Hours of Badovir Raw Material Mill	1,713	1,326	
Operating Hours of Badovir Mill Electrostatic Precipitator	225	300	
Downtime Hours of Badovir Precipitator	1,488	1,026	
Total Downtime Hours of the Precipitator	2,702	2,318	
Quantity of Dust Settled During Precipitator Operation and Returned to Production	0,45	0,45	
Quantity Emitted into the Air During Precipitator Downtime	1,216	1,043	
Total Plant Costs	6,177,764,443	5,160,448,083	
Production Quantity	126,234	140,260	
10% of Cost per Ton	4,894	3,679	
Environmental Costs Resulting from Raw Material Mills Precipitator Downtime	5,951,104	3,837,187	

Table Prepared by the Researcher Based on the Plant's Financial Data

4. Clinker Production Stage:

Table (5) shows the environmental costs for the clinker production stage. The highest environmental costs were recorded in 2022, amounting to **36,774,504 IQD**, while in 2023, the environmental costs were lower, totaling **30,703,606 IQD**.

Table 5: Environmental Costs for the Clinker Production Stage at Badoush New Cement Plant for 2022 / 2023

Details / Clinker Production	Raw Materials / Ton		Notes
	2022	2023	
Quantity of Materials Entering	118,201	131,334	
Outputs from the Process	116,181	129,090	
Waste	2,020	2,244	
60% Abnormal Waste	1,212	1,346	
Total Plant Costs	6,177,764,443	5,160,448,083	
Production Quantity	126,234	140,260	
62% of Cost per Ton	30,342	22,811	
Environmental Costs of Lost Materials / IQD	36,774,504	30,703,606	

Table Prepared by the Researcher Based on the Plant's Financial Data

Environmental Costs Resulting from the Use of Fuel Oil:

The calculation of environmental costs of fuel oil usage in the clinker production kilns in Badoush New Cement Plant has been done in Table (6). In 2023, the environmental costs caused by waste pollution were 12,470,094 IQD and this figure is greater as compared to 2022. This is 3% of the value of waste, and in 2022, the expenses were 11,223,085 ibn Ibrahim Quwain.

Table 6: Environmental Costs Resulting from the Use of Fuel Oil in Kilns at Badoush New Cement Plant for 2022 / 2023

Details	Years		Notes
	2022	2023	
Quantity of Clinker Produced	116,181	129,090	
Standard Consumption Rate per Ton of Clinker Produced: 120 Liters	13,941,720	15,490,800	
Actual Consumption per Ton of Clinker Produced: 140 Liters	16,265,340	18,072,600	
Waste Quantities / Liters	2,323,620	2,581,800	
Fuel Oil Price: 150 IQD per Liter + 11 IQD Transport	374,102,820	415,669,800	
Environmental Costs: 3% of Waste Value	11,223,085	12,470,094	

Table Prepared by the Researcher Based on the Plant's Financial Data

5. Cement Production Stage:

Table (7) shows the environmental costs for the cement production stage. The highest environmental costs were recorded in 2022, amounting to **290,760,968 IQD**, while the lowest environmental costs in 2023 amounted to **30,023,768 IQD**.

Table 7: Environmental Costs from Waste in the Cement Production Stage at Badoush New Cement Plant for 2022 / 2023

Details / Cement Production	Raw Materials / Ton		Notes
	2022	2023	
Quantity of Clinker Entering	130,175	137,026	
Quantity of Added Gypsum	3,877	4,308	
Quantity of Output	126,234	140,260	
Waste	7,818	1,074	
80% Abnormal Waste	6,254	859	
Total Plant Costs	6,177,764,443	5,160,448,083	
Production Quantity	126,234	140,260	
95% of Cost per Ton	46,492	34,952	
Environmental Costs of Lost Materials / IQD	290,760,968	30,023,768	

Table Prepared by the Researcher Based on the Plant's Financial Data

6. Packaging Stage:

Table (8) shows the measurement of environmental costs for the packaging stage. The highest environmental costs were recorded in 2022, totaling **146,817 IQD**, while in 2023, the environmental costs were lower, amounting to **125,093 IQD**.

Table 8: Environmental Costs from Abnormal Waste in the Packaging and Marketing Stage at Badoush New Cement Plant for 2022 / 2023

Details	Measurement Units	Years		Notes
		2021	2022	
Cement Consumed (Sold)	Ton	126,234	140,260	
Quantity of Bagged Cement Sold	Ton	100,987	112,208	
Quantity of Unbagged Cement Sold	Ton	25,247	28,052	
Abnormal Waste	Ton	3.0	3.4	**Waste: 0.003%**
Total Expenses	IQD	6,177,764,443	5,160,448,083	
Cement Production	Ton	126,234	140,260	
Cost per Ton of Produced Cement	IQD	48,939	36,792	
Environmental Costs from Abnormal Waste	IQD	146,817	125,093	**Calculation: Quantity of Waste × Cost per Ton**

Table Prepared by the Researcher Based on the Plant's Financial Data

Additional Environmental Costs:

Table (9) shows the environmental costs borne by the plant to reduce environmental damage from production processes. These costs amounted to **39,685,496 IQD** in 2023, which is higher than in 2022, when the costs were **39,644,230 IQD**.

Table 9: Additional Environmental Costs, Including Cleaning Workers, Medical Supplies, and Other Environmental Costs at Badoush New Cement Plant for 2022 / 2023

Details	Measurement Units	Years		Notes
		2022	2023	
1. Cleaning Workers				
Temporary Workers	**Number**	11	11	
Annual Salary Rate	**IQD**	3,600,000	3,600,000	
Total Wages	**IQD**	39,600,000	39,600,000	
2. Medical Supplies		44,230	0	
3. Others				
Fines for Non-Compliance with Environmental Safety Regulations		0	0	
Compensation for Environmental Damages		0	0	
Tree Planting and Green Areas		0	85,496	
Employee Equipment (Uniforms)		0	0	
Environmental Costs		39,644,230	39,685,496	

Table Prepared by the Researcher Based on the Plant's Financial Data

Comparison of All Stages for Badoush New Cement Plant:

Table 10: Total Environmental Costs from Abnormal Waste for All Stages at Badoush New Cement Plant for 2022 / 2023

Details	Badoush New Cement Plant				Notes
	2022	Percentage of Total Environmental Costs	2023	Percentage of Total Environmental Costs	
Research, Development, and Design Stage	3,543,752	0.40%	2,894,688	0.54%	
Quarries and Crusher Stage	55,534,665	6.30%	46,399,280	8.72%	
Raw Material Mills Stage	438,600,280	49.72%	366,347,462	68.80%	
Environmental Costs Due to Raw Material Mills Precipitator Downtime	5,951,104	%0.67	3,837,187	0.72%	
Clinker Production	36,774,504	4.17%	30,703,606	5.77%	

Stage					
Kiln Pollutants (for Clinker Production)	11,223,085	%1.27	12,470,094	2.34%	
Cement Production Stage	290,760,968	32.96%	30,023,768	5.64%	
Packaging and Marketing Stage	146,817	0.02%	125,093	0.02%	
Other Environmental Costs, Including Cleaning Workers and Medical Supplies	39,644,230	%4.49	39,685,496	7.45%	
Total Environmental Costs	882,179,405	100%	532,486,674	100%	

Table Prepared by the Researcher Based on the Plant's Financial Data

Table (10) above shows the total environmental costs for the product life cycle stages at Badoush New Cement Plant for 2022 and 2023, as well as the percentage of environmental costs for each stage relative to the total environmental costs. The total environmental costs were highest in 2022, amounting to **882,179,405 IQD**, while in 2023, the environmental costs were lower, totaling **532,486,674 IQD**. The highest percentage of environmental costs was observed in the raw material mills stage in 2023 at **68.80%**, representing the largest share of total environmental costs across the cement production life cycle stages. The lowest percentage of environmental costs was in the packaging stage, at **0.02%**, which is negligible compared to the raw material mills stage and the cement production stage, which in 2022 accounted for **32.96%**.

Table (11) shows the percentage of environmental costs for each stage of the cement production life cycle relative to the total plant costs at Badoush New Cement Plant Expansion. The percentage of total environmental costs relative to total plant costs was highest in 2022 at **14.285%**, while in 2023, it was **10.316%**, lower than in 2022. The highest environmental cost ratio relative to total plant costs was in the raw material mills stage at **7.10%**, consistent for both 2022 and 2023. The lowest ratio was in the packaging stage at **0.002%**, which is almost negligible for both 2022 and 2023.

Table 11: Percentage of Environmental Costs for Each Stage of the Product Life Cycle Relative to Total Costs at Badoush New Cement Plant for 2022 / 2023

Details	Years		Notes
	2022	**2023**	
Research, Development, and Design Stage	0.057**%**	0.06**%**	
Quarries and Crusher Stage	0.90**%**	%0.90	
Raw Material Mills Stage	7.10**%**	%7.10	
Environmental Costs Due to Raw Material Mills Precipitator Downtime	%0.096	0.074**%**	
Clinker Production Stage	0.60**%**	0.59**%**	
Kiln Pollutants (for Clinker Production)	0.18**%**	0.24**%**	
Cement Production Stage	4.71**%**	0.58**%**	
Packaging and Marketing Stage	%0.002	0.002**%**	
Other Environmental Costs, Including Cleaning Workers and Medical Supplies	0.64**%**	0.77**%**	
Total Environmental Costs	14.285**%**	%10.316	

The table was prepared by the researcher based on the factory's financial data.

Indicators of competitive advantage.

Among these indicators are:

First: The ratio of waste to inputs.

Table (12). The ratio of waste to inputs for the New Badoush Cement Plant for the years 2022/2023.

Details	Years	
	2022	2023
The research, development, and design stage	37,245%	36,708%
The quarrying and crushing stage	9,700%	9,700%
The raw material milling stage	55,823%	55,824%
The clinker production stage	1,708%	1,708%
The cement production stage	5,832%	0,759%
The packaging, labeling, and marketing stage	0,003%	0,003%
The total ratio of waste to inputs	110,311%	104,702%

The table was prepared by the researcher based on the financial data of the two plants.

From Table (12) above, the ratio of waste to inputs for the product life cycle of the New Badoush Cement Plant was calculated, from the research and development stage through to the packaging and readiness-for-marketing stage, using the following equation:

The ratio of waste to inputs = (Total inputs − good outputs) × 100%

Total inputs

The ratio in 2023 was (104.702%), which is lower than that of 2022, which amounted to (110.311%). The lower the ratio, the better the performance.

Second: Cost per ton

Table (13) The cost per ton for the Badoush Cement Expansion Plant and the New Badoush Cement Plant for the years 2021/2022/2023.

Details	Years	
	2022	2023
The total costs of the plant	6,177,764,443	5,160,448,083
Total production (tons)	126,234	140,260
Cost per ton	48,939	36,792

The table was prepared by the researcher based on the financial data of the two plants.

From Table (13) above, the cost per ton for the New Badoush Cement Plant for the years 2022 and 2023 is presented. The cost per ton was calculated using the following equation:

Cost per ton = Total costs (including environmental costs)

Total production (tons)

The cost per ton is considered one of the indicators used in assessing competitive advantage; the lower the cost, the better the competitive advantage of the cement plant. The lowest cost per ton

was recorded in 2023, amounting to (36,792) dinars per ton, whereas the cost per ton in 2022 was higher, reaching (48,939) dinars per ton.

Third: Environmental cost per ton

Table (14) The environmental cost per ton for the New Badoush Cement Plant for the years 2022/2023.

Details	Years	
	2022	2023
Total environmental costs	**882,179,405**	**532,486,674**
Total production (tons)	126,234	140,260
Environmental cost per ton	6,988	3,796

The table was prepared by the researcher based on the financial data of the two plants.

In Table (14) above, the environmental cost per ton of cement was calculated after obtaining the total environmental costs by measuring the environmental costs for each stage of the cement product life cycle. The environmental cost per ton was calculated using the following equation:

Environmental cost per ton = Total environmental costs

Total production (tons)

The lowest environmental cost was recorded in 2023, amounting to (3,796) dinars per ton, while the environmental cost in 2022 was (6,988) dinars per ton. The lower the environmental costs, the better, indicating the plant's commitment to the environment and society and its efforts to reduce waste and pollution.

Conclusions

Through the practical aspect of the study, several conclusions were reached, including:

1. The stoppage of the raw material mill causes significant environmental impacts as well as additional environmental costs arising from the annual downtime hours. Although its percentage relative to total costs is small, it represents an environmental gap that can be addressed and controlled.
2. The absence of environmental fines or compensations for environmental damages at the New Badoush Cement Plant indicates the plant's compliance with environmental standards and regulations, granting it a competitive advantage through reputation and environmental commitment toward the environment and society.
3. The ratio of waste to material inputs in 2023 was (104.702%), which is better than in 2022, where it reached (110.311%). The lower the waste ratio, the better the indicator of competitive advantage, reflecting lower pollution and reduced material and cost wastage.
4. The environmental costs at the raw material milling stage were higher than in other stages of the product life cycle, accounting for (68.80%) of total environmental costs in 2023, indicating that the raw material milling stage is the most environmentally harmful.
5. The cost per ton in 2023 was (36,792) dinars per ton, which is better than in 2022. The lower the cost per ton, the better the indicator of competitive advantage.
6. The environmental cost per ton was lowest in 2023, amounting to (3,796) dinars per ton, which is better than in 2022. The lower the environmental cost per ton, the better the indicator of competitive advantage.

Based on the study results, the following recommendations can be formulated:

1. Reducing or eliminating the downtime hours of the electrostatic precipitator for the raw material mills, along with proper and continuous maintenance, will reduce waste, thereby decreasing environmental pollution and costs, which helps improve competitive advantage through reputation and environmental commitment toward the environment and society.
2. The plant management should work on reducing waste, improving resource efficiency, and minimizing organizational risks, which will positively impact competitiveness.
3. Allocate funds for afforestation and green spaces near the plant to reduce the harmful environmental impacts resulting from production operations.
4. Fully transition to using natural gas for furnace operations instead of heavy fuel oil to reduce the harmful environmental effects associated with its use.
5. Work on reducing environmental costs at the raw material milling stage by minimizing waste and upgrading the electrostatic precipitator to a more advanced system that reduces pollutant emissions from production processes.

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