

# The Effect of Green Maintenance on Environmental Performance Applied Research in the General Company for Oil Products

Amer Abdul Latif KADHUM<sup>1</sup>, Huda Adeeb HAMEED<sup>2</sup>

<sup>1</sup> Middle Technical University, Technical College of Management, Iraq

<sup>2</sup> Rusafa Institute of Administration, Department of Materials Management Technologies, Iraq

Received: 05 February 2023

Accepted: 11 April 2023

## Abstract

The research aims to determine the effect of green maintenance “energy efficiency, health and safety risks, and environmental compatibility“ on environmental performance “environmental condition, operational performance, and management performance“ as analytical research in oil products distribution company by distributing a questionnaire distributed to 46 people. The research problem lies in the weak use of traditional maintenance technology, which negatively affects the environment. The research found that the research company’s reliance on green maintenance is weak in adopting new mechanisms and technologies to enhance environmental performance and the weakness of the efforts exerted by management in the field of environmental performance and the failure to involve its staff in training programs to create a culture of preserving the environment within the culture of the organization. The research recommends the need to use machines with low energy consumption and reduce the volume of pollution.

## Keywords

Green maintenance environmental performance, Operational and management performance indicators.

## Introduction

Attention to the environment has become more important in recent years at all individual, organizational, and international levels, and it has become imperative for factories to assume their responsibilities towards society and the environment in which they operate, by reducing the amount of waste and pollutants that result from manufacturing processes and treating them by adopting new approaches and methods in manufacturing. The maintenance function is important to explore the impact of maintenance on the company’s business. Energy efficiency, health and safety risks, environmental compatibility, and environmental conditions such as machine speed, load, operator, quality of maintenance, and production method all affect the life of the machine. There-

fore, the evaluation of machine condition and the effect of improvements in maintenance effectiveness and accuracy on plant activities (Ajukumar & Gandhi, 2013). It can be effectively achieved in environmental performance if information from work areas related to environmental performance indicators such as environmental condition indicators and environmental performance indicators are considered. Operational performance and management performance indicators simultaneously (Henri & Journeault, 2008; Tung et al., 2018; Jasch, 2009).

Kazemi (2013) also showed that asset-intensive industries, such as the construction industry, were exposed to accidents that led to major disasters that negatively affected their objectives. These incidents may threaten the continuity of companies due to the disruption of their physical assets, which are a major resource for their operations. Failure of physical assets can lead to serious safety and environmental consequences, as well as financial losses. Thus, ensuring the continuity of physical assets can enhance the competitive advantage of asset-intensive companies. For this reason, implementing well-established continuity and contingency plans can enhance companies’ resilience against disruptions. The term maintenance includes

**Corresponding author:** Amer Abdul Latif Kadhum – Middle Technical University, Technical College of Management, Iraq, e-mail: [dr.amer2017@mtu.edu.iq](mailto:dr.amer2017@mtu.edu.iq)

© 2023 The Author(s). This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>)

various procedures and tasks that are necessary to maintain the system in a normal condition during the life cycle and plays an important role with the aim of increasing or maintaining the reliability and availability of equipment, product quality and safety requirements. In addition to fulfilling equipment inspection, lubrication and repair requirements, it contains additional response for plant protection, pollution prevention, personnel safety and waste disposal. Although it often seems to managers that maintenance activities are just an expense, we should know that maintenance is not an expense; Investing in the future as basic functions of the company in order to improve the manufacturing and production process. It is one of the most important ways to achieve sustainable development (Ararsa, 2012), so it must highlight sustainability, which covers environmental, social, and economic issues and helps organizations meet their demands without negative effects on the needs of future generations, with priority given to physical assets. According to ISO 55000, critical physical assets have a significant impact on organizational goals and are vital for service providers to serve their primary customers. The concept of green maintenance has emerged as environmentally friendly, and has been adopted by small and large industrial organizations as part of their commitment to environmental, social, ethical and even economic responsibility towards society and the environment. It guarantees its survival, continuity and growth. Therefore, the current research came as an attempt to monitor the ability of senior management in organizations to find ways to improve their ability to adopt strategies that support the green maintenance system in order to reduce waste and pollutants throughout the product life cycle. Finally, the maintenance function is important to explore the impact of maintenance on the company's business.

Herefore, the research problem crystallized with many questions, most notably, does the company's management in question have a clear vision and perception of green maintenance? What is the level of interest of the company under study in environmental performance? What is the level of verification? In light of this, the opinions of the workers in the oil products distribution company were surveyed to be analyzed through a set of statistical means to come out with a set of conclusions and recommendations in line with the nature of the research. However, there is a lack of empirical studies that dealt with green maintenance and its impact on environmental performance within the organization in order to create Maintenance is environmentally friendly, especially in developing countries like Iraq.

## Literature review

### The concept of maintenance

The deterioration of the global ecosystem has caused an increase in public interest in environmental performance and forced many industries to use environmental policies to design products, manufacturing, services, and waste disposal activities (Ajukumar & Gandhi, 2013). For this reason, the transition from hardware and software to service and maintenance is changing the shape of the world; however, the understanding of maintenance is poor compared to traditional manufacturing, so there is a great need for tools and methods to understand control and predict failures. Hence, maintenance is a complete partner that strives with other functions to achieve the strategic objectives of the organization (Kazemi, 2013).

The term maintenance refers to all activities that aim to maintain an item in the physical condition necessary to achieve its production function or return it to its previous state, and these activities include routine service, periodic inspection and preventive replacement in addition to proactive monitoring (Irajpour et al., 2014) as well (Stevenson, 2018) explained that maintenance represents all activities that aim to maintain facilities and equipment in good working condition so that the system performs its work as required.

Proper maintenance of plant and equipment systems is essential to the safe, reliable, and efficient performance of equipment in any industry. Faulty or poor maintenance is a factor of financial loss (Khalquzzaman et al., 2010). Proper maintenance can also contribute to improved performance. The overall performance of the business through its impact on the quality, efficiency, and effectiveness of the organization's operations, sustainability, and access to productivity advantages, value advantages, and long-term profitability, enhances the competitiveness of the organization (Oliva et al., 2013).

Maintenance is divided into two types (Heizer et al., 2017): Preventive maintenance: Preventive maintenance involves monitoring equipment and facilities, performing routine inspections and servicing, and maintaining facilities in good condition, to build a system that will reduce variance, identifying potential failures, and make changes. Or repairs that maintain efficient operations, the current generation of advanced sensors allows managers to build systems that can detect even the slightest abnormal vibration, and minute changes in temperature or pressure, and preventive maintenance includes designing technical and

human systems that keep the production process running within permissible limits. This allows the system to work as designed.

**Remedial maintenance:** It occurs when the system or equipment stops working or when preventive maintenance fails intending to return it to its previous condition before stopping. The equipment or facilities must be repaired on an emergency or priority basis.

### The concept of green maintenance

It is one of the most important ways to achieve sustainable development of society, in addition to its economic functions, it has important social functions. It plays an important role in rationalizing energy use, reducing emissions, developing a recycling economy, and building a resource-saving and environmentally friendly society (Ararsa 2012; Kayan et al., 2017) as an assessment tool that provides a sustainable solution to long-term maintenance in terms of the cumulative impact on the environment. Zhang et al. (2017), he defined it as the rational use of maintenance resources to reduce environmental pollution and avoid waste in maintenance operations. He also mentioned (Ajukumar & Gandhi, 2013) that green maintenance is an attempt to make maintenance less environmentally friendly by eliminating all waste and waste associated with maintenance operations. He also defined it (Kazemi, 2013) as a technological method for maintenance by disposing of waste associated with the maintenance process and rationalizing the use of resources to achieve sustainable development. More than other methods of maintenance as it represents the outcome of the interaction of a group of philosophical factors related to social and economic factors in terms of cost and the development of an economy capable of facing fluctuations, in addition to the environmental impacts that are increasingly oriented towards it (Kayan et al., 2018) as shown in Figure 1.

It is noted in the literature and concepts mentioned above that the global transformation into a sustainable, environmentally friendly economy made companies face the challenge of shifting towards green operations of supplying, manufacturing and marketing, as well as maintenance operations, which are an integral link in this direction to achieve competitive advantage or exit from the markets. Green maintenance is a method for maintaining devices and equipment aimed at eliminating waste and environmental impacts associated with the maintenance process and optimizing the use of available resources.

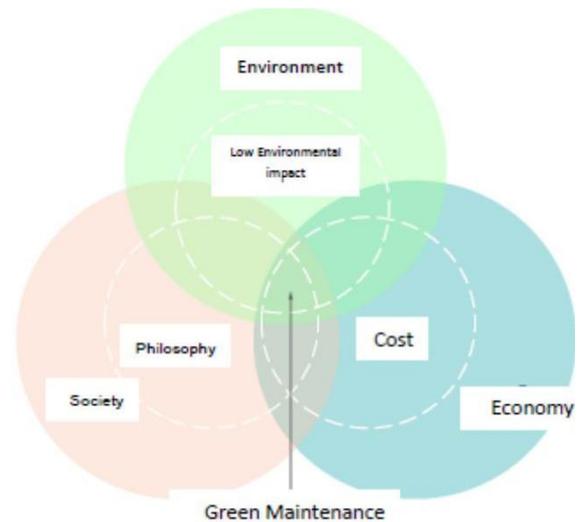


Fig. 1. Conceptual Model of Green Conservation, Source: (Kayan et al., 2017; Kayan et al., 2018)

### The benefits of green maintenance

Adopting the green maintenance method achieves for the organization a set of benefits, the most important of which are adapted (Ajukumar & Gandhi, 2013):

1. Reduce the problems caused by leaks.
2. Reducing the problems associated with waste disposal operations.
3. Reducing the negative impact on the environment by adopting effective waste treatment policies.
4. Urging organizations to use environmentally friendly maintenance materials such as (lubricating oils, and cleaning materials).
5. Maintaining the health and safety of workers by reducing the risks associated with maintenance operations and the use of non-toxic materials.
6. Using technology in the maintenance process and moving away from traditional maintenance.
7. Use of energy-saving maintenance materials and equipment.

### Green maintenance requirements

The use of green maintenance is linked to a set of requirements that must be met in its operations (Ajukumar & Gandhi, 2013).

1. **Energy Efficiency:** Maintenance is necessary even with efficient systems as it keeps them in good condition and without sudden stops. It also plays an important role in improving energy efficiency through a set of technologies that contribute to improving operation and production (Pons et al., 2013). Machines and equipment are a source of

energy consumption in factories and homes alike, so using the saving ones greatly reduces energy consumption, but at the same time it is subject to sudden breakdowns and stops that affect the system, which affects its production and operational capacity, so it should be followed. An effective strategy in maintenance operations from preventive, predictive and scheduled maintenance programs to discover and diagnose faults, avoid failure and achieve growth in the global rationalization of energy use (Kappatos, 2021).

2. **Health and Safety Risks:** Healthy green maintenance practices are the cornerstone of their success. Emitted gases, leak sites, lubricating oils, filters, hoses, and containers often cause health problems. Green maintenance is responsible for providing a safe and reliable environment through implementing each of the steps in Maintenance in a proper manner while providing appropriate protection for maintenance workers and others on the work sites. Therefore, green maintenance seeks to use safe materials in its operations such as the use of environmentally friendly biodegradable fluids, non-toxic materials, and long-life lubricants (Ajukumar & Gandhi, 2013)
3. **Environmental Compatibility:** The organization's quest to develop an effective system for maintenance requires it to take a comprehensive look at the internal and external conditions and the strategy surrounding its work, and then determine how future changes to those conditions affect the efficiency of its performance in particular and environmental performance in general (Jasiulewicz & Drozyner, 2013), the emitted gases and organic compounds resulting from maintenance operations lead to a high risk of injuries among maintenance workers, as well as their negative impact on the surrounding environment in the long run.

Therefore, it should take into consideration these factors (energy consumption, health, and safety risks, and environmental compatibility) and the requirements that are generated by maintenance operations as they are considered the main catalyst for their survival in the market because ignoring them makes them evade their social and environmental responsibility, which affects their reputation.

### **The second axis: Environmental performance – the concept of environmental performance**

Environmental performance literature shows that organizations of different nature of their activities and regulators did not pay much attention to this neglected area until the 1960s, and one of the most im-

portant reasons for this neglect was the limited knowledge of policymakers regarding toxic emissions resulting from the operations of organizations, then developed basic pollution measurement techniques, but unfortunately, it was not easily available to the different stakeholders (Mohammad, 2014), so the concept of environmental performance in the past two decades attracted the attention of organizations around the world including industrial and service organizations and governments, which led to an increase in pro-environmental behaviors before implementing environmental regulations. Environmental management and approval of its certificates (Massoud et al., 2010). Al-Mawali (2021) defined environmental performance as the environmental impact resulting from the organization's management of its various activities of harmful recycled waste and gaseous emissions and non-compliance with laws and regulations environmental. As for (Wang et al., 2015), he explained that environmental performance is the relative performance of the organization in complying with environmental regulations interactively and proactively that allows the occurrence of environmental crises and trains workers on environmental issues. As for the Organization for Standardization (ISO), it defined environmental performance in brief as the results of the organization's management of its environmental aspects (Trumpp et al., 2013). While Yang et al. (2011) indicated that environmental performance is the degree to which an organization improves its performance about its environment. Also defined (Walls et al., 2012) is environmental performance as the environmental impact resulting from the strategic activities managed by the organization. While both Tibor & Feldman (1996) and Schultes & Reis (1995) went to almost agreement on finding a detailed definition of environmental performance, they defined it as the training period that the organization undertakes in addressing the relationships between all aspects of the risks of its activities and the environmental impacts of obtaining results measurable (Kola-Lawal, 2015).

It is clear from the above that effective environmental management and improving the organization's environmental performance, which the researcher defined as "a measure to determine the environmental impact of the organization's consumption of resources and its efforts to reduce the negative impact on the environment" creates many viable advantages, as it is considered a competitive priority for them because they have become aware that Proactive environmental activity can contribute to reducing unwanted accidents and improving economic outcomes at the same time.

## Environmental performance indicators

Environmental performance indicators (EPI) are an essential tool to achieve the objectives of the environmental dimension in economic organizations of all kinds. During which their environmental performance is improved, and the environmental performance indicators differ according to different organizations and their activities, as they can be divided into several categories: (Tung et al., 2018; Henri & Journeault, 2008; Jasch, 2009).

1. Environmental condition indicators: These indicators provide information about the local, regional, national or global environmental condition. They directly measure the quality of the environment. They are used to assess the impact of emissions on air and water quality, for example, air quality in power plants and water quality. Industrial and noise pollution at airports and indicators of environmental conditions are usually monitored and recorded by public institutions.
2. Operational performance indicators: These indicators provide information about the environmental performance of the organization's operations, as these indicators form the basis for evaluating the environmental aspects. They are directly related to the balance of material flow between inputs and outputs, the operation of facilities, equipment, and supply chains, as well as the waste resulting from the organization's operations.
3. Management performance indicators: These indicators provide information about the efforts made by the management to influence the environmental performance of the organization as well as the results achieved about the impact on its environmental aspects, such as the number of environmental reviews, employee training, supplier audits, cases of non-compliance, implementation of Environmental policies, compliance of procedures with requirements and expectations, financial performance related to the environment, etc., they provide useful information that allows setting goals for improving the environmental management system.

## Environmental management systems

The International Standardization Organization (ISO) defines an environmental management system (EMS) as a part of a general management system that includes the organizational structure, planning activities, responsibilities, practices, procedures, processes, and resources for the development, implementation, investigation, analysis, and maintenance of environmental policies (Herghiligi, 2018). Pesce et al.

(2018) indicated that the first emergence of environmental management systems in North America in the 1970s and now widely used by organizations around the world was developed to overcome the shortcomings of traditional tools as they provide Guidelines in addressing environmental issues. Herghiligi et al. (2019) stated that environmental management systems are dedicated to managing environmental aspects and impacts and cannot be considered an independent tool, but rather a subset of the overall management system.

Perotto et al. (2008) stated that environmental management systems were developed according to the Deming principle (planning, doing, examination, implementation) and thus can be presented as an independent cycle of planning, implementation, re-evaluation, and improvement of organizational processes for continuous improvement of environmental performance.

Teodosio explained that the main objectives of the environmental management system are (Herghiligi, 2013).

1. The Environmental Management System identifies and controls the environmental aspects, impacts, and risks associated with them.
2. The compliance of the implementing organizations of the Environmental Management System with the agreed environmental policies and regulations.
3. The Environmental Management System sets out the basic principles that develop the environmental responsibilities of organizations.
4. The Environmental Management System defines the responsibilities, authorities, and procedures that ensure the participation of human resources.
5. Developing an integrated environmental program that would raise the level of organizational performance while balancing costs and benefits.

## Impact of environmental management systems on environmental performance

There are conflicting opinions about the relationship between environmental management systems and environmental performance, as some researchers claim that adopting any pro-environmental behavior such as implementing an environmental management system leads to improving environmental performance (Jabbour et al., 2012), and others have pointed out that the impact of environmental management systems The multi-dimensional environment can be seen from different angles (Bioral, 2011).

1. Environmental management systems provide a general mechanism to drive organizations to undertake more responsible environmental practices.

2. More proactive environmental management may improve other non-environmental indicators such as indicators of financial performance and the organization's general performance.

At the same time, studies and research have proven that the implementation of the environmental management system has positive effects on environmental indicators such as energy and water use, waste treatment, dealing with by-products associated with the process of productivity, and recycling. The same studies have shown that obtaining an environmental management certificate (EMS) reduces generation rates. Solid waste shows the importance of environmental management systems in improving environmental performance (Kola-Lawal, 2015).

### Research implications

The current research differed from previous studies in the following areas:

1. The application site, as this study was applied in the Iraqi environment in the industrial sector, focusing on petroleum products.
2. The current research dealt with the application of green maintenance in environmental performance, as it highlights the difference in (Maletic et al., 2014) in terms of identifying and removing losses in the current manufacturing line, and improving potential areas from the company's perspective, while the current research in terms of focusing on energy efficiency and risks Health, safety and environmental compatibility.
3. The current research dealt with the costs associated with the improvements resulting from the application of green maintenance and the extent to which the respondents could adopt new mechanisms and technologies to enhance environmental performance.

The research dealt with the descriptive analysis approach using the questionnaire, as it differed from the approach of previous studies, such as the study (Al-Najjar, 2007) that adopted the (VBM) model in assessing the financial impact, and the study (Maletic et al., 2014) the case study approach, and the study (Maletic et al., 2018) modeling the path of squares Partial Minor (PLS-PM), and the study (Paralikadu, 2014) Multi-criteria Decision Analysis (MCDA) according to the solution method, decision category, and asset category, and the study (Rezaei, 2023) the quantitative method of physical asset analysis (BIA) basic in the implementation of business continuity management

Maintenance is now an important component of asset management, and green maintenance has the

biggest impact. Thus there are previous studies looking at maintenance as part of asset management and its role on sustainability. The environmental performance of the organization comes as an indicator of the organization's interest in the environment and society (environmental status indicators and operational performance indicators) and the way to achieve that is through green maintenance with its requirements (energy efficiency, safety and health risks, and environmental compatibility), and environmental management systems.

## Materials and methods

### The research problem

The research problem can be embodied in the following questions:

1. Does the management of the company in question have a clear vision and perception about (green maintenance)? What is the level of application for this maintenance?
2. What is the company's level of interest in environmental performance? What is the level of verification?
3. Is there a significant correlation between green maintenance and environmental performance in the company understudy?
4. Is there a significant effect of green maintenance on the environmental performance of the company understudy?

### Research objectives

The research objectives that derive from the research problem are determined in:

1. Determining the extent to which the company under consideration applies green maintenance.
2. Diagnosing the level of environmental performance in the company under investigation.
3. Determine the extent to which there is a significant correlation between green maintenance and the environmental performance of the company under investigation.
4. Diagnose the extent to which green maintenance has a significant effect on the environmental performance of the company under study.

### The importance of research

The importance of the research stems from the benefits it achieves for the company in question, as it revolves around two variables whose importance crystallizes in the results of the impact of green maintenance on environmental performance, and therefore

the importance aspects center in considering it one of the modern maintenance systems that contribute to increasing its production and enhancing its environmental performance.

**Research hypotheses**

The hypotheses were built based on the relationship and influence between the research variables and the differences between the company under investigation in the level of the two variables and their sub-dimensions. In this direction, two main hypotheses were crystallized as follows:

The first main hypothesis (H1): There is a significant correlation between green maintenance and environmental performance.

The second main hypothesis (H2): Green maintenance has a significant effect on environmental performance.

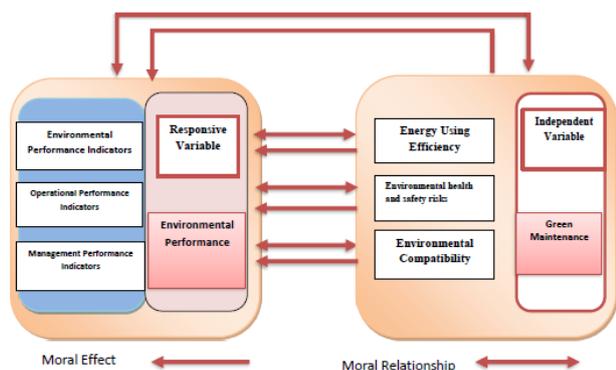


Fig. 2. The hypothesis of the research

**Research methodology**

The research relied on the descriptive analytical approach that achieves a holistic view in describing and analyzing the case, is consistent with the idea and objectives of the research, and determines the strength of the variables within the framework of the responses of the sample members to the questionnaire paragraphs, as well as accessing documents and records, and conducting personal interviews as methods for collecting data and information to ensure giving An overview of the variables under study.

**Sources and methods of data collection**

1. The theoretical side: Arab and foreign books, periodicals, dissertations and theses, Arab and foreign university theses that dealt with research variables, research, and specialized articles were relied on (the Internet).

2. The practical aspect: the research was based on the practical aspect of the following methods in collecting information and analyzing the data collected from the researched company using a questionnaire form. Strongly Agree 5, agree 4, neutral 3, disagree 2, and Strongly disagree 1 to classify the response degrees that range between 5-1 degrees, with the large degree of the most agreed group determined.

**The research community and sample**

The research community includes all (450) employees of the Petroleum Products Distribution Company. As for the sample, it consisted of senior management managers, directors and heads of departments, divisions, factories and laboratories in the researched company, as they are decision-making centers, and they are responsible for achieving the company’s goals. Their number reached 5 managers. The community, as the number of respondents to the questionnaire, was as shown in Table 1.

Table 1

The number of distributed questionnaires that are valid for analysis and non-refundable, and the recovery rate in the researched company

The company	Number of distributed questionnaires	Number of questionnaires Valid for analysis	Number of non-retrievable questionnaires	Recovery rate %
The General Company for Electrical and Electronic Industries	54	46	8	85%
Grand Total	54	46	8	85%

From looking at Table 1, it is clear that the intentional sample whose responses were approved for the purposes of the research amounted to 46 managers, who constitute 85% of the total community of managers, and the personal characteristics of the individuals of the research sample who were answered for the purposes of the research can be viewed by looking at the following:

It is clear from Table 2, in the researched company, the personal characteristics of the members of the research sample, including the following:

1. Gender: The percentage of males dominated females in the company, at a rate of 83%.
2. Age: The age group 40–49 appeared at a rate of 41.3%, as they occupy leadership positions as they are in contact with the company’s factories and

Table 2  
 Characteristics of the sample members in the oil products distribution company

	Gender	Male				Female				46				
1		38		%83		8		%17		%100				
2	The age	30–39		40–49		50–59		60 and over		46				
		7	15.2	19	41.3	17	37	3	6.5	%100				
3	Qualification	Technical, Degree		Diploma		Bachelor's		Master's		46				
		5	10.8	31	67.4	17	37	3	6.5	%100				
4	Duration of service in the company	Less than 5		5–9		10–14		15–19		20 and over	46			
		0	0	1	2.1	9	19.7	17	36.9	19	41.3	%100		
5	Type of company activity	Productive		Service		Productive and service				46				
		78	78.9	4	4	8	8.1			%100				
6	Current job in the company	Director general	Members of the Board of Directors (senior management)	Assistant General Manager	Factory managers	Laboratory managers	Heads of Departments			46				
		1	2.1	2	4.4	5	10.8	1	2.1	2	4.4	5	17.4	%100

laboratories, in addition to being a category characterized by greater mental and physical energy and possessing experience and skill in the field of work.

- Academic qualification: It is clear from the nature of the industrial or productive work in the business practiced by the company, its impact was clear in strengthening the company with leaders with good academic qualifications, as holders of a bachelor's degree in the company reached the largest percentage of the percentages of other certificates, so they were in the company at a rate of 67.3%.
- Duration of service in the company: It turned out that the service of the managers in the company is more than 20 years.
- The type of the company's activity: the number of managers in the production departments was more than the other departments in the company, as they were in the company at a rate of 87.9% since the company is one of the production companies.
- The current position in the company: The factory managers were the most numerous in the company, being in contact with the workers inside the factory and the closest in decision-making, as the percentage of factory managers in the company was 50%.

It is clear from the above that the response of the research sample was represented mostly by males between the age of (40–49) years, holding a bachelor's degree, a period of service in the researched company of 20 years, working in the production departments, and being managers of the researched company's factories.

### The apparent honesty test

For the questionnaire used in the research to meet the approved scientific conditions, the paragraphs of the resolution measures were presented to a group of specialized arbitrator professors, in this field to ensure the apparent validity of the measurement tool, and to determine the ability of the paragraphs to cover the field to which they belong, and in the light of their opinions about the clarity of each paragraph in terms of the intellectual content and formulation, several paragraphs were corrected, with the addition or deletion of several paragraphs for any of the two variables according to the opinions of the arbitrators and reviewed by the research hypotheses and objectives, the stability of the measurement tool is intended, and by adopting the Alpha Cronbach coefficient the stability of the resolution was measured.

## Results

### Stability test – Alpha Cronbach

The stability test is evidence of stability and objectivity in the answers of the study sample in different periods, and it is one of the most common measures in previous studies (Table 3). Alpha-Cronbach for the questionnaire items at the level of all its dimensions lies between 0.721 and 0.902, which are high values compared to the minimum acceptance of 0.60, while the content validity values were located between 0.85 and 0.95, which indicates the possibility of passing. The questionnaire is in addition to the homogeneity of the questionnaire's paragraphs and its validity for all its objectives.

Table 3

Calculate the stability of (Alpha-Cronbach) and the validity of the content

Study variables and dimensions	Number of items	Alpha-Cronbach coefficient	Content validity
Energy Efficiency	8	0.743	0.862
Health and safety risks	8	0.762	0.873
environmental compatibility	8	0.792	0.89
Green Maintenance (Independent Variable)	24	0.864	0.93
Environmental Performance Indicators	5	0.721	0.85
operational performance indicators	5	0.725	0.851
management performance indicators	5	0.781	0.884
Environmental Performance (Dependent Variable)	15	0.767	0.876
For all paragraphs of the questionnaire	39	0.902	0.95

### Descriptive analysis and presentation and analysis of results

Table 4 refers to the description and analysis of the sample's opinions about the study variables "green maintenance, environmental performance", as it is clear that the arithmetic mean of the green maintenance variable reached 2.31 and with a standard deviation

of 0.52, which indicates the presence of weakness and lack of interest of the organization (place of the study) Applying green maintenance practices, as it obtained after (energy efficiency) an arithmetic mean of 2.31 and a standard deviation of 0.66, which indicates that the organization (the place of study) did not use modern technology in maintenance operations in order to reduce pollution sources in addition to its lack of reliance on programs Scheduled to maintain devices and equipment and not to use environmentally friendly energy in order to get rid of waste that contribute to environmental pollution, which means that the efficiency of energy use by reducing consumption was not among the priorities of the organization (the place of study). While the (health and safety risks) obtained a mean of 2.27 and a standard deviation of 0.62, which indicates the weakness and lack of interest of the organization (the place of study) in the health risks resulting from maintenance operations as a result of its lack of dependence on correct green practices and its lack of interest in providing a safe, reliable and free environment of the gaseous emissions that affect the health and safety of the employer, what happened after (environmental compatibility) with arithmetic mean 2.36 and a standard deviation 0.51, which indicates a lack of interest as a result of the company's lack of interest in developing targeted programs to reduce injuries among maintenance workers due to their exposure to gases It emitted organic compounds, as well as not using environmentally friendly materials in its maintenance work.

As for the (environmental performance) variable, it obtained an arithmetic mean of 2.37 and a standard deviation of 0.51, which indicates the weakness of the organization (the place of application) in its environmental performance. 0.65, which indicates that the organization (the place of application) is not keen on taking care of the environment due to the lack of relevant information in the field of the environment, as well as the lack of monitoring of the organization's products on their impact on environmental indicators. Then (operational performance indicators) got an arithmetic mean of 2.36 and standard deviation 0.64, which indicates the large number of interruptions that occur in the production process for not using quantitative tools that contribute to achieving balance in the flow of materials and their use of machines and equipment that are not easy to maintain during the production process Which makes the operation time longer compared to the ideal situation. Then (management performance indicators) got an arithmetic mean of 2.29 and a standard deviation of 0.62, which indicates the weakness of the efforts made by the administration in the field of environ-

Table 4  
Descriptive analysis of the sample for the research variables

	Paragraphs	Repetitions					Arithmetic mean	Standard deviation
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree		
1	The company uses modern maintenance technology to reduce pollution sources.	2	3	13	11	17	2.17	1.00
2	The company adopts a method (scheduled programs) for the maintenance of devices and equipment aimed at getting rid of waste.	1	4	11	17	13	2.20	1.02
3	The company uses environmentally friendly energy (which has little negative impact on the environment) in the maintenance of its products.	2	8	9	18	9	2.48	0.98
4	Reducing the pollution of waste from its sources is a priority for the company.	3	2	10	19	12	2.24	1.01
5	Reducing energy consumption to a minimum is one of the company's priorities.	2	6	14	13	11	2.46	0.88
6	The company uses an effective strategy in maintenance operations from preventive, predictive, and scheduled maintenance programs to discovering faults.	3	3	12	19	9	2.39	0.79
7	The company emphasizes energy through a set of technologies that contribute to improving operation and production.	2	1	14	18	11	2.24	0.99
8	Diagnosing the company's faults, avoiding failure, and rationalizing the use of energy are among the company's priorities.	2	6	11	12	15	2.30	0.78
Energy Efficiency X1							2.31	0.66
9	The company's management adopts correct green maintenance practices, including health and safety.	0	3	10	21	12	2.09	0.86
10	The company's management undertakes green maintenance by providing a safe and reliable environment by properly implementing maintenance steps.	0	6	16	13	11	2.37	0.99
11	The company's management adopts a green maintenance strategy constantly to reduce health problems (emitted gases, containers, and lubricants).	1	2	9	21	13	2.07	0.92
12	The company uses safe materials in its operations, such as the use of environmentally friendly fluids (non-toxic materials, and long-life lubricants).	2	7	7	20	10	2.37	0.88
13	The company implements green maintenance practices while providing appropriate protection to maintenance workers and others on work sites.	2	4	14	14	12	2.35	1.00
14	The company views green maintainability as an essential part of its health and safety risks.	2	4	17	11	12	2.41	0.78
15	The Company reduces its health and safety risks to reduce and improve the costs of using resources.	1	7	13	12	13	2.37	0.79
16	The company's management takes care of health and safety risks and brings them closer to a safe and reliable environment.	1	1	12	21	11	2.13	0.88
Health and Safety Hazards X2							2.27	0.62
17	The company demonstrates an effective green maintenance system through a comprehensive look at internal and external conditions.	0	3	18	16	9	2.32	0.87
18	The company is characterized by the ease of determining how the company's future changes will affect the efficiency of its performance in particular and the environmental performance in general.	1	5	15	14	11	2.37	0.69

Table 4 continued

	Paragraphs	Repetitions					Arithmetic mean	Standard deviation
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree		
19	The company reduces the risk of injuries among maintenance workers (such as emitted gases and organic compounds).	6	2	6	22	10	2.39	0.89
20	The company adopts green maintenance to reduce its negative impact on the surrounding environment in the long run.	2	6	10	15	13	2.33	0.81
21	The company uses environmentally friendly maintenance materials (such as lubricants and cleaning materials).	2	7	10	17	10	2.43	0.84
22	The company minimizes problems associated with waste disposal operations.	1	4	10	20	11	2.22	0.98
23	The company has effective waste treatment policies.	1	6	16	17	6	2.54	0.95
24	The company focuses on more than one policy in reducing the problems caused by diversions.	1	5	8	23	9	2.26	0.98
Environmental Compatibility X3							2.36	0.51
Green Maintenance X							2.31	0.52
25	The company is keen to provide information about the local, regional and global environment.	3	5	12	17	9	2.47	0.74
26	The company's products are monitored in terms of indicators of environmental conditions.	2	1	10	24	9	2.2	0.67
27	The company can measure the quality of the environment to assess emissions (air and water quality).	3	5	14	14	10	2.5	0.82
28	Affects air quality in power plants, industrial water quality, and noise.	3	5	13	15	10	2.49	0.61
29	The company uses specific (14001) standards on air quality in power plants, industrial water quality, and noise.	3	8	15	12	8	2.7	0.82
Environmental Status Indicators Y1							2.47	0.65
30	There are no interruptions in the production process that lead to a long cycle time.	0	3	12	15	16	2.04	0.94
31	It does not affect the time of completion of the process in the time of other operations.	0	7	12	19	8	2.39	0.95
32	The company uses quantitative tools directly related to material flow balance.	2	3	13	16	12	2.28	0.49
33	The company's machines are easy to repair during the production process.	2	4	10	22	8	2.35	0.62
34	The company depends on the operation of facilities and equipment and how to dispose of waste resulting from the production process.	5	3	19	13	6	2.74	0.76
Operational Performance Indicators Y2							2.36	0.64
35	The company makes efforts to influence the environmental performance of the organization.	1	5	13	16	11	2.33	0.79
36	The company submits the results achieved from (training of employees, number of environmental audits, and supplier audits) that have an impact on its environmental aspects.	2	4	13	18	9	2.39	0.67
37	No choke points occur during production when moving from one process to another.	1	3	10	24	8	2.24	0.89

Table 4 continued

	Paragraphs	Repetitions					Arithmetic mean	Standard deviation
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree		
Operational Performance Indicators Y2							2.36	0.64
38	Availability of information about the company about management efforts to influence environmental performance.	0	3	15	15	13	2.17	0.93
39	Availability of information with the company about setting goals to improve the environmental management system.	1	4	13	19	9	2.33	0.97
Management Performance Indicators Y3							2.29	0.62
Environmental performance y							2.37	0.51

mental performance and the lack of involvement of its staff in training programs to create a culture of environmental preservation within the culture of the organization, as well as the lack of efforts to obtain information and data received in the local, regional and global environment.

### The normal distribution test

The results of Table 5 indicate the normal distribution of the data, as the Shapiro-wilk test for the green maintenance variable reached 0.978 and the level of significance 0.545, while the Shapiro-Wilk test for the environmental performance variable reached 0.957. At the level of significance 0.091, which indicates that the data distribution is characterized by the characteristic of a normal distribution, since the two values of the level of significance (Sig) are greater than the level of significance (Sig = 0.05), which is considered the minimum to consider the data with a normal distribution, and therefore the data have a normal distribution.

Table 5  
Test data distribution

Variable	Will	Sig	Distribution type
Green maintenance X	0.978	0.545	Natural
Environmental performance Y	0.957	0.091	Natural

### Hypothesis testing

1. Testing the hypotheses of the relationship between green maintenance and environmental performance

The sub-correlation hypotheses are tested, and then the main correlation hypothesis is tested to confirm the acceptance or rejection of the hypotheses. From Table 6, it is clear that the values of the correlation

Table 6  
The relationship between green maintenance and environmental performance with its dimensions

Element of the independent variable	The dependent variable and its dimensions				
		Environmental status indicators Y1	Operational performance indicators Y2	Management performance indicators Y3	Environmental performance Y
Energy Efficiency X1	Spearman Correlation	0.291*	0.528**	0.40**	0.490**
	Sig. (2-tailed)	0.04	0.000	0.006	0.001
Health and Safety Hazards X2	Spearman Correlation	0.421**	0.463**	.602**0	0.662**
	Sig. (2-tailed)	0.004	0.001	0.000	0.000
Environmental compatibility X3	Spearman Correlation	0.463**	0.531**	0.432**	0.608**
	Sig. (2-tailed)	0.001	0.000	0.003	0.000
Green maintenance X					0.664**
					0.000

coefficient between the independent variable and its dimensions (green maintenance) and the dependent variable and its dimensions (environmental performance) ranged between 0.664\*\* and \*0.291 at a significant level that ranged between 0.000 and 0.000, which is less than 0.05. This indicates that there is a statistically significant direct correlation between green maintenance and its dimensions and environmental performance and its dimensions. The relationship between health and safety risks and environmental performance represented the strongest relationship 0.662, and the relationship between energy efficiency and environmental condition indicators was added by 0.291, and therefore we accept the correlation hypothesis, which indicates that the green maintenance variable and its dimensions in the researched company have an active and important role In the environmental performance variable, as it represented the strongest relationship among the other relationships.

**Test hypotheses of the effect of green maintenance on environmental performance**

This paragraph deals with testing the influence hypotheses identified by the research for the purpose of determining the possibility of judging the acceptance or rejection of the influence hypotheses, as this will be done according to the simple linear regression equation as follows (Table 7):

$$Y = a + \beta X$$

The significance of the estimated model shows that the probability values associated with the F test statistics have reached (sig = 0.000), which is less than the value of the level of statistical significance ( $\alpha = 0.05$ ), which indicates the acceptance of the effect hypothesis. Below is the equation of the simple regression line:

$$Y = 1.22 + (0.499)X_1 + 1.173 + (0.529)X_1 + 0.905 + (0.622)X_1 + 0.718 + (0.715)X$$

**Discussion**

1. Does the management of the company in question have a clear vision and perception of (green maintenance)? What is the level of implementation of this maintenance? It appeared that there was weakness and lack of interest in the researched company in applying green maintenance practices, and the researched company did not use modern technology in maintenance operations in order to reduce pollution sources, in addition to its lack of reliance on scheduled programs for maintenance of devices and equipment, and its lack of use of environmentally friendly energy in order to get rid of waste that contributes to environmental pollution.
2. What is the level of interest of the company under study in environmental performance? What is the level of verification? The researched company's lack of interest in the environment appeared due to the lack of information related to the environment, as well as the lack of monitoring the organization's products about their impact on environmental indicators. Frequent stoppages in the production process for not using quantitative tools that contribute to balancing the flow of materials and using machines and equipment that are not easy to maintain during the production process, which makes the processing time longer compared to the ideal situation. the weakness of the efforts made by the administration in the field of environmental performance and the failure to involve its staff in training programs to create a culture of preserving the environment within the culture of the organization, as well as the lack of efforts in obtaining information and data related to the local, regional and global environment.
3. Is there a significant correlation between green maintenance and environmental performance in the researched company? There is a significant correlation between green maintenance and environmental performance in the researched company

Table 7  
Analysis of variance for the green maintenance variable in the environmental performance variable

Independent variable	Regression coefficient		R <sup>2</sup>	T	F	Sig	Dependent variable
	A	B					
Energy Efficiency	1.22	0.499	0.421	5.767	32.010	0.000	Environmental performance
Safety and health risks	1.173	0.529	0.428	5.408	32.869	0.000	
Environmental compatibility	0.905	0.622	0.393	5.333	28.478	0.000	
Green maintenance	0.718	0.715	0.545	7.256	52.652	0.000	

because of its active and important role in environmental performance variable.

4. Is there a significant effect of green maintenance on the environmental performance of the researched company? The effect of green maintenance on environmental performance.

## Conclusion and recommendations

### The conclusions

This study reviews the most important conclusions and recommendations of the research, as follows:

1. Green maintenance is one of the green operations that aim to get rid of waste and environmental impacts associated with the maintenance process and optimal use of resources.
2. The importance of applying green maintenance techniques is increasing through the use of technology and moving away from traditional maintenance to reduce the negative impact on the environment by adopting effective waste treatment policies.
3. The environmental performance helps the researched company to achieve the environmental impact resulting from the company in question's management of its various activities of harmful recycled waste and gas emissions and others.
4. The results of describing and diagnosing the research variables indicate the consensus of working individuals about the necessity of their company to implement green maintenance tools, as well as their consensus about encouraging their company to achieve the dimensions of green maintenance.
5. The results of the correlation and the effect between the research variables confirmed the existence of a relationship between green maintenance and environmental performance. As for the effect, there is a strong effect of green maintenance on environmental performance.
6. The company's weak adoption of green maintenance in adopting new mechanisms and techniques to enhance environmental performance.

### The recommendations

1. The company's management enhances the levels of application of dimensions by setting a schedule for green maintenance, taking into account sudden stops and how to treat them without affecting the workflow.
2. Spreading the culture of green maintenance among the employees of the researched company, and relying on them to reduce the amount of indus-

trial waste and environmental pollutants through (posters, holding seminars, and workshops on environmentally friendly products, .... etc.).

3. Using machines with low energy consumption, which contributes to reducing their effects on the environment, reducing the volume of pollution and energy consumed, and holding training courses to clarify the contents (health and safety risks, energy efficiency, environmental compatibility), and the benefits achieved by the company as a result of its application.
4. Adopting control systems that follow up on green maintenance to enhance environmental performance, as well as a policy that obliges the companies affiliated with the company in question to follow green maintenance that contributes to reducing environmental pollution and enhancing their competitive performance.

### Acknowledgments

We would like to thank the General company for oil products for providing us with the information required to implement the study.

### References

- Ajukumar, V.N., & Gandhi, O.P., (2013). Evaluation of green maintenance initiatives in design and development of mechanical systems using an integrated approach. *Journal of Cleaner Production*, 51, 34–46.
- Al-Mawali, H. (2021). Environmental cost accounting and financial performance: The mediating role of environmental performance. *Accounting*, 7, 535–544.
- Al-Najjar, B. (2007). The lack of maintenance and not maintenance which costs: A model to describe and quantify the impact of vibration-based maintenance on company's business. *International Journal of Production Economics*, 107(1), 260–273.
- Ararsa, B.B. (2012). *Green Maintenance: A Literature Survey on the Role of Maintenance for Sustainable Manufacturing*. Master thesis, School of Innovation, Design, and Engineering, Malardalen University.
- Boiral, O. (2011). Managing with ISO systems: Lessons from practice. *Long Range Planning*, 44(3), 197–220.
- Delmas, M., & Blass, V. D. (2010). Measuring corporate environmental performance: The trade-offs of sustainability ratings. *Business Strategy & The Environment*, 19, 245–260
- Heizer, J., Render, B., & Chuck, M. (2017). *Operations Management: Sustainability and Supply Chain Management*, 12<sup>th</sup> ed., Pearson Education Inc., USA.

- Henri, J.F., & Journeault M. (2008). Environmental performance indicators: An empirical study of Canadian manufacturing firms. *Journal of Environmental Management*, 87, 165–176.
- Hergiligi, I.V., (2018). EMS Exploratory Analysis in order to improve its Integration Quality through Fractal Design. *Journal Procedia Soc. Behav*, 238, 597–606.
- Hergiligi, I.V. (2013). *Researches Regarding Environmental Management System as a Complex Process at the Organizational Level*. Ph.D. Thesis, University of Angers, Angers, France.
- Hergiligi, I.V., Robu, I.B., Pislaru, M., Vilcu, A., Asandului, A.L., Avasilcai, S., & Balan, C. (2019). Sustainable Environmental Management System Integration and Business Performance: A Balance Assessment Approach Using Fuzzy Logic. *Sustainability Journal*, 11, 1–30.
- Irajpour, A., Najafabadi, A.F., Mahbod, M.A., & Karimi, M. (2014). A Framework to Determine the Effectiveness of Maintenance Strategies Lean Thinking Approach. *Mathematical Problems in Engineering Journal*, 1, 1–11.
- Jabbour, Ch., Govindan, K., Teixeira, A.A., & Freitas, W., (2012). Environmental management and operational performance in automotive companies in Brazil: The role of human resource management and lean manufacturing. *Journal of Cleaner Production*, 47, 129–140.
- Jasch, Ch. (2009). *Environmental and Material Flow Cost Accounting*, 4<sup>th</sup> ed., published by Springer.
- Jasiulewicz-Kaczmarek, M., & Drozyner, P., (2013). The Role of Maintenance in Reducing the Negative Impact of a Business on the Environment. In: Erechtkoukova, M., Khaite, P., Golinska, P. (eds) *Sustainability Appraisal: Quantitative Methods and Mathematical Techniques for Environmental Performance Evaluation*, pp. 141–166. EcoProduction. Springer, Berlin, Heidelberg.
- Kappatos, V. (2021). *Energy: Climate and the Environment*, 7<sup>th</sup> ed., Springer, Germany,
- Kayan, B.A., Halim, I.A., Mahmud, N.S. (2018). Green Maintenance For Heritage Buildings: An Appraisal Approach For St Paul's Church In Melaka, Malaysia. *International Journal of Technology*, 7, 1415–1428.
- Kayan, B.A., Zaid, N.S.M., & Mahmud, N.S. (2017). Green Maintenance Approach: Low Carbon Repair Appraisal on St Paul's Church, Melaka, Malaysia. *Journal of Design and Built Environment*, Special Issue, 116–130.
- Kazemi, S. (2013). Proposing a Green Maintenance Model in Order to Analyses the Effects of Influential Criteria on the Environment and Green Maintenance Index, Using System Dynamics Method. *Advances in Environmental Biology*, 7(11) 3529–3534.
- Khalaquzzaman, M., Kang, H.G., Kim, M.C., & Seong, P.H. (2010). Quantification of unavailability caused by random failures and maintenance human errors in nuclear power plants. *Nuclear Engineering and Design*, 240, 1606–1613.
- Kola-Lawal, C.O. (2015). *Investigating The Relationship Between Pro-Environmental Behavior and Environmental Performance Through Development and Application of a Model For Categorizing Environmental Management System Implementation Factors*. Ph.D. Thesis, College of Science and Technology, University of Salford, Salford, UK.
- Maletič, D., Maletič, M., Al-Najjar, B., & Gomišček, B. (2014). The role of maintenance in improving company's competitiveness and profitability: a case study in a textile company. *Journal of Manufacturing Technology Management*, 25(4), 441–456. DOI: [10.1108/JMTM-04-2013-0033](https://doi.org/10.1108/JMTM-04-2013-0033).
- Maletič, D., Maletič, M., Al-Najjar, B., & Gomišček, B. (2018). Development of a model linking physical asset management to sustainability performance: An empirical research. *International Economic Journal of Production*, 10(12), 4759.
- Massoud, M. A., Fayad, R., El-Fadel, M., and Kamleh, R. (2010). Drivers, barriers and incentives to implementing environmental management systems in the food industry: A case of Lebanon. *Journal of Cleaner Production*, 18(3), 178–189.
- Mohammad, N. (2014). *Corporate Environmental Performance and its Impact on Financial Performance and Financial Risk: Evidence from Australia*. Ph.D. Thesis, University of Waikato.
- Oliva, M., Weber, B.I., (2013). PRM\_based Patterns for Knowledge formalization of industrial systems to support Maintenance Strategies Assessmen. *Reliability Engineering and System Safety*, available on [10.1016/j.res.2013.02.026](https://doi.org/10.1016/j.res.2013.02.026).
- Paralikadu, K. (2014). Asset Management Literature Review on Multi-Asset Systems. *Cambridge University Journal*, 181, 181–201.
- Perotto, E., Canziani, R., Marchesi, R., & Butelli, P. (2008). Environmental performance, indicators and measurement uncertainty in EMS context: A case study. *Journal of Cleaner Production*, 16, 517–530.
- Pesce, M., Shi, C., Critto, A., Wang, X., & Marcomini, A. (2018). SWOT Analysis of the Application of International Standard ISO 14001 in the Chinese Context. A Case Study of Guangdong Province. *Sustainability*, 10, 3196.
- Pons, M., Bikfalvi, A., Llach, J., & Palcic, I. (2013). Exploring the impact of energy efficiency technologies on manufacturing firm performance. *Journal of Cleaner Production*, 52, 134–144.
- Rezaei, K., (2023). A quantitative framework for BIA analysis based on the critical importance of physical

- assets in the context of sustainability and resilience. *International Economic Journal of Production*, 13(1), 264.
- Stevenson, W.J. (2018). *Operation Management*, 13<sup>th</sup> ed., McGraw hill, USA.
- Schultes, R.E., & Reis, S.V. (1995). *Ethnobotany: Evolution of a Discipline*. Dioscorides Press, Portland.
- Tibor, T., & Feldman, I. (1996). *ISO14001: A Guide to the New Environmental Management Standards*. Toronto, CA: Irwin Professional Publishing.
- Trumpp, J.E., Zopf, C., Guenther E., & Guenther, E. (2013). *Definition, Conceptualization, and Measurement of Corporate Environmental Performance: A Critical Examination of a Multidimensional Construct*, Published by, Springer, 1–20.
- Tung, A., Baird, K., & Schoch, H. (2018). The effectiveness of using environmental performance measures, *Australasian Journal of Environmental Management*, 21, 1–16.
- Walls, J.L, Berrone, P., & Phan P. H. (2012). Corporate Governance and Environmental Performance: Is There Really A Link. *Strategic Management Journal*, 4, 1–29.
- Wang, Y., Chen, Y., & Benitez-Amadoc, J. (2015). How information technology influences environmental performance: Empirical evidence from China. *International Journal of Information Management*, 35, 160–170.
- Yang, M.G. Hong, P., & Modi, S.B. (2011). Impact of lean manufacturing and environmental management on business performance: An empirical study of manufacturing firms. *Production Economics*, 129, 251–261.
- Zhang, F., Xie, X., & Yan, Ch., (2017). Evaluation System and Implementation Countermeasure of Automobile Green Maintenance. *Conf. Series: Earth and Environmental Science*, 108, 1–7.