Al-Qadisiyah Journal for Administrative and Economic Sciences ISSN$_{Online}$: 2312-9883
QJAE, Volume 28, Issue 2 (2026) ISSN$_{Print}$: 1816-9171
DOI:/ /doi.org/10.33916/qjae.2026.02512528

Quality Control Tools to Enhance Sustainable Quality - A Survey Study in a Plant of Intravenous Solutions - Nineveh

L.a Rayan Mohammed Thyab
College of Administration and Economics
University of Mosul

Received: 04/03/2026
Accepted: 06/06/2026
Available online: 30/06/2026

Corresponding Author: rayan Mohammed

Abstract*:* This study examines the role of quality control tools in achieving sustainable quality in production processes. These tools are essential for improving process efficiency, enhancing product quality, and supporting environmental sustainability through the development of eco-friendly and renewable products. The study adopts a multidimensional perspective that includes economic, social, health, and cultural aspects.

The research addresses the question: What is the role of quality control tools in achieving sustainable quality? The Intravenous Solutions Plant – Quality Assurance Department was selected as the case study. Data were collected using a questionnaire distributed to 80 respondents, with a full response rate. Statistical analysis was conducted using SPSS.

The results reveal a significant correlation and impact of quality control tools on sustainable quality. The findings also indicate a high level of implementation of quality practices within the organization. The study recommends strengthening organizational efforts and establishing clear policies to ensure compliance with quality and environmental standards.

Keywords: Seven Quality Control Tools, Sustainable Quality, Quality Control, Plant of Intravenous Solutions, Quality Assurance.

1. Introduction:

Sustainable quality has become a critical objective for industrial organizations seeking to improve operational performance, enhance product quality, and achieve environmental and economic sustainability. In this context, quality control tools play an essential role in monitoring production processes, identifying defects, reducing waste, and supporting continuous improvement. The seven quality control tools are widely recognized as effective techniques for analyzing problems and improving process efficiency.

This study aims to examine the role of quality control tools in achieving sustainable quality in the Intravenous Solutions Plant – Quality Assurance Department. The research focuses on identifying the relationship and impact between quality control tools and sustainable quality practices within the organization. The study adopted a descriptive analytical approach, and data were collected through a questionnaire analyzed using SPSS.

The findings indicate a significant relationship and impact between quality control tools and sustainable quality, highlighting the importance of adopting effective quality practices and continuous improvement to ensure compliance with quality and sustainability standards.

Chapter One: The Research Framework

First: The Research Problem: In light of the increasing challenges faced by organizations across various sectors, there is a growing need to adopt comprehensive and systematic solutions that address problems at their root causes, whether arising from internal or external environments. In this context, the application of statistical and quality control tools has become essential for monitoring production processes, improving product quality, and enhancing the performance of quality assurance departments.

However, despite the recognized importance of these tools, there remains a lack of clarity regarding their actual role and effectiveness in achieving sustainable quality within organizations. This is particularly relevant in the researched company, where the need persists to identify appropriate mechanisms and practices that ensure continuous quality improvement while aligning with sustainability requirements. Accordingly, the research problem is addressed through the following questions:

1. To what extent do the quality assurance department and employees utilize the seven quality control tools in the researched field?
2. To what extent does the company adopt the concept of sustainable quality to enhance its products?
3. Is there a significant relationship between quality control tools and sustainable quality?

Second: The Importance of Research:

The importance of the research lies in identifying the theoretical aspect that deals with the two research variables, identifying their concepts, and demonstrating the importance of the seven quality control tools used in the quality assurance department of the intravenous solutions factory, as a field for applying the research. This is done by knowing the descriptive background about the reality of the researched factory and obtaining information about the practical reality of quality control tools and their impact on sustainable quality.

Third: Research Objectives:

* To examine and clarify the responsibilities of employees in the quality control and quality assurance departments by assessing the sustainability of resources, the adequacy of sampling procedures, and the degree of compliance with established specifications. This is achieved through the application of appropriate quality control and monitoring tools, which contribute to reducing pollution, minimizing waste, and limiting defects within the researched factory.

To identify and evaluate the levels of quality and to determine effective approaches for sustaining and continuously improving these levels over time.

To analyze the nature of the relationship between the research variables by examining both the correlation and the causal impact between quality control tools and sustainable quality.

Fourth: Research Hypotheses:

* H1: There is a statistically significant correlation between quality control tools and sustainable quality at the level of the research field.

H2: Quality control tools have a statistically significant effect on sustainable quality at the level of the research field..

Fifth: Research Community and Sample

* Defining the study population is one of the important axes because it contributes to the success or failure of the study, and it represents the main source for obtaining data and reaching accurate results. The intravenous solutions factory, one of the factories of the General Company for the Pharmaceutical and Medical Supplies Industry in Samarra, was selected after the merger, and it specializes in the production of (2) types of intravenous solutions. Currently, the possibility of producing distilled water W.F.I is added. Previously, it worked on the bag system, and it is the only

factory in Iraq that supplies the Ministry of Health, private hospitals, and warehouses with intravenous solutions at that time. The factory was exposed to acts of vandalism during the events of 2003, and the damage rate reached 100%. The rest of the factory's facilities were rehabilitated by the Turkish company Axen Med, with funding from the 2011 investment plan, and new buildings and service facilities were added, such as a guesthouse, an administration building, a nursery, a rabbit field, and new warehouses for marketing and spare parts, to become the total building area (7000) m2. The factory was also exposed in 2017 to civil damage as a result of military operations to liberate Mosul from the control of ISIS terrorist gangs. The factory was rehabilitated in all its departments and completely for the period from (May to October 2018), and the effects of destruction were removed and all machines and equipment were operated, and we are awaiting the Ministry of Health and Environment to visit the factory and evaluate its compliance with the pharmaceutical industrial specifications GMP.

* The factory, which is one of the departments of the General Company for the Pharmaceutical and Medical Supplies Industry - Nineveh, operates according to the following methodology:

* The factory produces intravenous solutions and medical supplies according to the highest requirements and approved international pharmaceutical compendia.

* The factory seeks to achieve competition with its products, enhance customer satisfaction, and continuously improve performance as an approach to achieve the company's quality goals.

* Based on the awareness of the importance of development and enhancing the ability of workers to give, the factory management and its cadres are committed to applying the requirements of the international standard specifications (ISO 9001:2015) and periodically reviewing the quality management system to ensure its continuous development.

Sixth: Research Methodology

This research relied on the descriptive analytical approach in writing the theoretical and applied framework because it helps researchers in collecting data and information related to the research with finding various means and interpreting them in addition to obtaining results according to observations and comparisons and relying on the questionnaire tool in order to collect data and information and study it and reach results for the research problem

Chapter Two: Theoretical Framework of the Research

First Axis: Quality Control Tools

Introduction

Today, more than ever, there are multiple reasons that drive service and production institutions and organizations to adopt sustainability. This serves as an attraction for investors to achieve hopes and ambitions for growth and expansion, and to meet the expectations and desires of customers and increase their satisfaction. It has become a necessity, not a choice, which has enhanced the importance of sustainability through providing products, services, and processes with sustainable quality according to the methods and principles of quality management. In the rapidly evolving business environment, sustainability is no longer just a common or trendy term, but has become an urgent necessity for companies that are exposed to increasing pressures to reduce their environmental footprint. But where do we start? How? And when? This is through a solid and robust quality management system that relies on measuring and analyzing results and matching them through the seven quality tools to achieve strict and efficient control, starting from the raw material and achieving the effective use of resources and managing simplified operations that contribute to reducing the consumption of raw materials and energy, up to the final stages reaching the customer. These are essential steps towards sustainable quality to identify shortcomings in production and operations and reduce environmental impacts. This is what the quality management system and its tools ensure by complying with legal and industrial standards, which reduces risks and avoids penalties while promoting environmentally friendly practices.

Theoretical Conceptual Framework: Quality Control (QC): Conceptual Framework, Importance, and Historical Development

Undoubtedly, the history of quality control is as old as industry and its revolution. During the Middle Ages, quality control was achieved through long-term training of workers to refine operations and enhance their skills. They took pride in the training because it enhanced product quality. Until the early 19th century, the factory system began in Great Britain in the mid-1850s, followed by the development of the industrial revolution and its impact in the early 19th century, and what the American quality practices changed and affected (Leong, et al., 2014, 1) (Neyestani, 2017, 13). Quality control is considered the process of ensuring the implementation of the basic tasks and tasks for building a high-quality system and a reform system to the highest quality standards and meeting the necessary requirements and specifications. Quality control includes a number of steps that include planning, implementation, and monitoring. Effective quality control is necessary to accomplish the requirements of the quality system on time, within the allocated budget, and with the highest quality standards (Kustikova & Pankova, 2023, 1).

The figure(1) below illustrates the historical development of quality control.

SORUCE : Shyam Narayan Gupta, Piyush Yadav, Shradha Sahu, Mukesh Yadav, Ritesh Maurya,2022,4, A Review: Quality Control, International Journal of Creative Research Thoughts (IJCRT) www.ijcrt.org

"Quality control is the process of quality reviews for all factors involved in production and is defined according to ISO 9000 as part of quality management that focuses on meeting quality requirements according to the results of measurements and analysis that are documented with the readiness of laboratories that prove the validity of measurements with documented evidence to provide accurate analytical results in a timely manner while taking responsibility for the quality of their work and product developments to ensure that they meet the standards and conditions of quality and efficiency (Shyam, et al, 2021, 2) Quality control is an integrated system." "To maintain product standards by testing a sample of outputs according to specifications, there are four basic types of quality control: (Priyanka, 2020, 2)

1. Process control, which focuses on company processes.
2. Sample inspection during the acceptance stage, during which samples are taken to set inspection plans.
3. Conformity inspection stage, in this stage the sample that has been produced is matched according to the specifications that have been designed.
4. Product quality control stage, and in this stage continuous follow-up is carried out and ensuring that the company produces high-quality products. In addition to that, quality control is the process of setting standards and testing to ensure that the product and service are manufactured correctly, for example, the control is carried out in a production unit factory designed to inspect the assembly of each element correctly (Priyanka, 2020, 3)"

According to Demirkaya, quality control is considered a fundamental pillar of the quality management system and represents a necessary requirement for maintaining the desired levels of quality (Demirkaya, 2022, 2). Claire Daffern defines quality control as a set of procedures that ensure data reliability in accordance with established standards and specifications, while protecting research processes from errors and risks. It involves continuous monitoring and documentation to ensure compliance with approved procedures and is considered an integral part of quality assurance. (Claire Daffern, 2024, 4). Olivia McDermott et al. (2022) found that the seven basic Ishikawa tools can solve most quality-related problems, with the Pareto chart being the most commonly used. These tools provide a structured approach to problem-solving, especially with strong management support. (Olivia McDermott, et al., 2022, 1).

Mitra (2019) defines quality control as a system for maintaining quality through feedback and corrective actions. Neyestani (2017) highlights Ishikawa's role in developing the seven quality control tools to solve problems and improve processes. (Neyestani, 2017, 3). The quality control tools were developed in Japan by quality experts such as Deming & Juran after World War II, and 95% of the problems can be solved using the seven tools in all stages of product development, design, and marketing (Varsha M. Magar, Dr. Vilas B. Shinde, 2014, 27).

Grigoryan and Golubkova (2020) emphasize that the seven quality control tools play a vital role in solving operational problems and supporting sustainable development in quality management systems. They view these tools as integrated methods encompassing economic, organizational, managerial, social, environmental, and technical aspects. (Ekaterina Grigoryan, Ilonna Golubkova, 2020, 528-529). Improving productivity has become extremely important for companies and organizations, and this is achieved through the use of the seven quality tools. Applying these tools is very easy for solving problems to meet the needs and aspirations of customers with high-quality products (Jaware, et al., 2018, 2796).

Secondly: Perspectives of Researchers and Writers and the Divisions of the Seven Quality Control Tools Quality Control (QC)

Opinions, perspectives, ideas, and names have varied according to the perceptions of many relevant researchers, writers, and quality pioneers such as Juran, Deming, and Ishikawa, and according to the following sources: (Ekaterina Grigoryan*, Ilonna Golubkova, 2020) (Behnam Neyestani, 2017) (Fatih Demirkaya, 2022) (Heena Sharma, Dr. N.M Suri, 2017) (Olivia McDermott, Jiju Antony Michael Sony, 2022) (Jaware, 2018) (Mohamed Abdel-Hamid, Hanaa Mohamed Abdelhaleem, 2019) (Matthew Barsalou, 2023) (Imdad Ali Memon, et al., 2019) (Lee, M. G., Chechurin, L., & Lenyashin, V. 2018) (Susatyo & et al., 2018) (Khairun Nadiyah, Grita Supriyanto Dewi, 2022)

The names and titles have differed, with some calling them the seven tools, while others call them Ishikawa tools, or graphical and statistical tools, or tools for identifying and solving critical quality problems, or the seven parameters for quality control, and the need for tools to achieve high quality when conducting a root analysis. These tools are used to analyze problems, generate ideas, and solve problems. Therefore, we will review these tools as follows:

1. Flowchart/Control and Monitoring Maps: The flowchart is one of the basic tools for studying the entire process, and through it, the steps of the process are represented step by step. The flowchart of the process is studied, starting from the raw material (raw materials) to the final product, and the process of graphical representation and understanding is facilitated (Jaware, 2018, 1). From another point of view, it is a formal graphical representation that ensures inputs, activities, decision points, and outputs with the aim of representing the main goal of the process, which is one of the problem-solving tools. It is a visual representation of the sequence of steps and decisions necessary to implement a process. It helps in studying, planning, improving, and communicating complex processes in a clear way to address defects and find solutions to problems and identify the

defect or gap in any step of the product process (Mohamed Abdel-Hamid, Hanaa Mohamed Abdelhaleem, 2019, 417).

2- Checklists / Inspection Logs: Sometimes referred to as inventory sheets, this is a basic, structured form that helps the user record and document data. Data is collected and organized on a verification sheet to record observations and the frequency of specific occurrences during the data collection and documentation period. It is considered a reliable and effective approach that can be applied to ensure and monitor quality to verify specific operations and follow them. It helps the user organize data and use it later, considering it as references and documented sources. Its most important advantages are ease of use, understanding the results, and forming a clear picture of the institution's situation (Mohamed Abdel-Hamid, Hanaa Mohamed Abdelhaleem, 2019, 418). It is an effective tool for identifying recurring problems and issues and the ability to analyze the quality of work efficiently. These records are a very important source of data collection for analysis purposes. Data is available in different forms depending on the nature of the application, including inspection logs, attendance and departure logs, maintenance and malfunction logs, and production and defect and damage logs (Jaware, 2018, 2)

3- Pareto Analysis or Chart: Named after the Italian economist Vilfredo Pareto, who discovered in the late 19th century that 80% of the wealth is owned by 20% of the people. This can be applied to commercial and economic operations. For example, 80% of a company's revenue comes from 20% of its customers, and 20% of products and services generate 80% of the profits, and 20% of the possible causes generate 80% of the problems and gaps in production and operations (Teplická et al., 2021, 137), or it is the theory known as the 20/80 rule, which is a diagnostic tool used to quickly and easily identify critical categories in the quality of operations, such as errors, elements, and activities. It is a tool that uses the cumulative relative frequency of the occurrence of phenomena and identifies the most important ones. This empirical principle relies on the general rule that some factors (elements) are responsible for their repeated occurrence in the total group, meaning that 80% of the total repetitions result from a relatively small number of types of elements, which Pareto chart explains (Lucia Čabaníková et al., 2025, 171) (Markulík et al., 2022, 6). The Pareto chart also addresses machine scheduling problems in wide applications in the field of manufacturing in order to improve resource utilization (Yazdani M, Haghani M, 2024, 133). Therefore, the Pareto chart is considered a model solution for production and quality scheduling problems as it provides a basic understanding and a simplified model of various performance measures and more complex solution techniques (Sona Babu, B.S. Girish, 2025, 2) (Morais et al., 2023, 24)

4. Graphs or Charts: They are a type of bar chart that displays a set of related data that can be used to assess the distribution and variation of data over a specific range, such as (weight, duration, size, age), which is illustrated by a bar shape or a curve for data distribution, which helps in determining the appropriate statistical tests and understanding the flaws using this information, and through it, it is possible to identify areas of focus for efforts towards quality improvement, and it is also considered a graph an effective tool for early detection of defects and errors in any institution or project, and it is useful for collecting basic information to focus on improvement efforts in high-volume procedures (NHS England and NHS Improvement, 2023, 2).

5- Cause and Effect Diagram or Fishbone Diagram: The fishbone diagram (Ishikawa diagram) is an important quality control tool used to identify the root causes of problems rather than their symptoms. It visually illustrates the relationship between various contributing factors—such as materials, machinery, human resources, methods, and environment—that may lead to quality issues. This tool supports systematic problem analysis and helps teams address multiple causes effectively (Trout, 2023). (Al Mardawi et al, 2021, 50) (Kumah A & Forkuo-Minka AO, 2023, 61) and after discovering the problems in the operations, it is necessary to identify their main causes, taking into account the various factors such as (human, material, machine, environment, process, style) (Augustine Kumah Et al, 2023, 1-3).

6. Scatter diagrams are a quality control and quality assurance tool used to determine the relationship between the actual quantity produced and the number of defects resulting from scratches or manufacturing errors due to human error, machine error, or deviations in measurements from the design. A linear relationship is built between the production quantity and the number of defects based on the results of calculating the correlation coefficient and the value of the correlation coefficient between errors and defects in the produced quantities. It is a statistical function that measures the relationship between the production quantity and the deficit, which can be positive or negative, which requires avoiding these defects and compensating for the lost deficit despite the high levels of production (Aulia Ishak Et al., 2020, 7).

7. Control Charts: A control chart is one of the quality control tools and is a statistical graphical technique used to examine the process to determine whether it is controlled and subject to statistical control at a specific point, known as the control center, or exceeds the upper limit at a specific point, which is known as the upper control limit (UCL), or decreases to the lower limit of the process (LCL). This indicates that the process and flows are out of statistical control and must be readjusted with more than one alternative scenario. Control charts enable us to use this information to assess whether there is a noticeable variation in a process resulting from a common cause, whether the variation is (inherent, random, integrated) in the process or resulting from a special, non-random routine cause. There are several types of control charts depending on the nature of the data used, which are variable (continuous) data and discrete (special) data, or the other type of data that we observe in the manufacturing and services sectors is of three types, the most prominent of which are:

A. Variable or measurable data and the graphs to measure it are R&X Bar & SIGMA.

B. non-measurable characteristics data, which are characteristics or attributes data such as defective fraction or non-conforming fraction, and the graph to measure it is usually a P chart.

C. Defect data or the number of defects in non-conformance cases, and the graph to measure it is a C chart for the number of defective units (Arun Kumar Sinha & Richa Vatsa, 2022, 574-577).

Third: Benefits and advantages of quality control tools and techniques: Applying quality control tools and techniques is very important to improve the performance of operations by reducing the variation of products and services as follows:

A. Improving production efficiency by reducing waste, loss, and rework.

B. Helps reduce rejection cases and rework.

C. Helps enhance customer satisfaction and loyalty by reducing the number of complaints.

D. Helps reduce production costs, which is reflected in the price of the produced unit, increased sales, and increased market share.

E. Helps in easily finding the root problems and quickly responding to address them and improve production performance (Heena Sharma & Dr. N.M Suri, 2017, 1582).

While Shyam Narayan Gupta and his colleagues say that quality control tools achieve other benefits and advantages, which are:

A. Consumer (customer) satisfaction, as consumers are the biggest beneficiaries of improving product quality, in other words, they get the best products from their favorite company.

B. Reducing production costs, meaning that whenever production processes are subject to control and inspection, the cost of the product decreases significantly, and quality control reduces waste,

especially when the production volume is large, which contributes to reducing direct costs and high quality.
C. Efficient and effective use of resources, and this is what quality control ensures through the optimal use of resources (natural, human, material, informational, environmental) to the fullest extent, which ensures control over all forms of inefficiency and waste.
D. Reducing inspection costs, and one of its benefits is quality control, thus significantly reducing inspection costs.
E. Increasing the improvement of the company's reputation, when manufacturing and providing high-quality products, customers feel satisfied, and thus it reflects on the company's reputation, which makes it easier to increase its funding and revenues.
F. Price stability, thanks to the quality control procedures and its seven tools, the company is able to produce products with the same level of quality and at the same prices as usual on an ongoing basis, which is a common problem for most companies in changing prices as a result of changes in shipping and transportation prices or customs tariffs or changing suppliers or suppliers. Scarcity of raw materials, high wages for the workforce, or taxes... etc. (Shyam Narayan Gupta Et al., 2021, 1923) The figure (2)below shows the types of seven quality control tools.
SOURCE: Fatih Demirkaya, The Quality Control Tools used for Sustainability of Quality ARCHIVES OF ENGINEERING KNOWLEDGE VOL. 7 ISSUE 1 (2022) 21-26 www.qpij.pl

Section 2: Sustainability of Quality

Concept of Quality Sustainability: Theoretical Framework: Concept and Importance: Many writers and researchers specializing in quality sustainability and how to achieve optimal quality control at the environmental, developmental, material, and human levels have addressed this, such as (Misztal & Ratajszczak, 2025) (Silva et al., 2021) (Czerwinska et al., 2025).
Since the 1980s, quality has evolved from a product- and service-focused concept to a comprehensive quality management system, particularly after the early 1990s. This shift reflects ongoing technological, economic, environmental, and social changes, which have increased the complexity and challenges faced by industrial organizations. (environmental, social, economic, technological) (Saniuk & Gajdzik, 2020, 12). In light of a global economy, the changing dynamic movement forces institutions to develop their capabilities according to market expectations, and this is what drives companies to pay great attention to improving the quality of manufactured products and the growth of knowledge, skills, and innovation (Ingaldi, & Ulewicz, 2020, 217).
Based on this, modern technology and innovation can be a significant competitive source by achieving remarkable progress in innovations and applying accumulated knowledge. Companies seek to identify the next development and build new strategies and models for production and operations management towards outstanding sustainable quality according to the concept of Industry 4.0. This is what quality control can implement and achieve through its seven tools and modern approaches and advanced technologies (robots, artificial intelligence, vision systems) to increase the accuracy and reliability of inspection processes with optimal use of energy (electricity). Quality control systems can perform detection operations quickly and with high accuracy and sustainably, while detecting non-conformities more efficiently and improving the accuracy and consistency of quality assessments and reducing the time and costs associated, which means reducing waste and predicting potential problems and suggesting corrective actions (Mandapaka & Diaz, 2023, 17) (Vu, & Chang, 2024, 24). Over the years, a wide range of management systems have been developed and focused extensively around quality management

theories and sustainability concepts such as environmental management systems, organizational sustainability, and occupational health and safety management systems. These systems are often targeted to achieve organizational goals under the umbrella of an integrated management system (Kutty et al., 2021, 2745). The integration of these concepts outside the traditional boundaries of any system leads to the emergence of a new concept, namely Sustainable Quality Management, which is a system that is viewed as a concept that intersects between environmental management systems, quality management system, and sustainability. It is worth noting that many authors have addressed sustainable quality management as a strategic tool that achieves the goals and aspirations of companies and organizations through reliable strategies to improve sustainable business through quality control tools (Kongar & Barraza, 2020, 48). The use of contemporary quality control methods and tools contributes to the sustainable development of the organization, and according to a statement by the CEO of the Quality and Reliability Institute, Vincent Desmond, today's quality is tomorrow's sustainability (Vincent Desmond, 2024, 7). Quality management is a strategic approach that supports corporate sustainability by integrating environmental, social, and economic aspects to achieve efficiency and effectiveness. (Kantabutra & Ketprapakorn, 2020, 270). In our contemporary time, manufacturing processes are vital to global economic growth, but they pose a major environmental threat to institutions and countries due to gas emissions and greenhouse gases that cause global warming and resource consumption. Therefore, it requires a doubled and intensive effort by quality control and assurance units in inspection rounds for manufacturing processes to maintain product standards, and the exacerbation of the environmental effects of manufacturing processes will increase the burden and costs (Haridy et al,. 2025, 2). Poor quality negatively affects the sustainability (economic, environmental, social) of production processes, and this leads to a lack of efficiency, increases waste, and undermines societal trust (Karuppiah et al., 2024, 79).

Statistical monitoring, testing, and inspection processes focus on reducing variance and improving quality, but they often avoid economic and environmental consequences, as they lack sustainable management strategies for managing non-conforming elements and controlling quality limits in many uncontrolled scenarios (Fonseca et al., 2021, 39). The modern approach to quality control integrates environmental and economic considerations by combining inspection processes with sustainability objectives. It enhances early detection of non-conforming products and environmental impacts, enabling timely corrective actions. This approach is particularly important in manufacturing, where it supports sustainability without compromising quality standards. (Cai et al., 2022, 16). This is what the Total Quality Management (TQM) tools have proven to achieve sustainable manufacturing (Rohkohl et al., 2023, 80). In addition, developing control and quality control units and making an actual improvement in production for product quality, manufacturing costs, and environmental effects (Gul et al., 2024, 302). The concept of corporate sustainability was also addressed by the researcher SILVA and his colleagues in their research published in 2021 entitled ((Sustainable Quality Management Systems, the current model and its pioneering role) It is defined as the leadership and management approach adopted by companies to achieve profitable growth while simultaneously achieving sustainable quality outputs (environmental, social, and economic). Corporate sustainability extends to a broader concept that demonstrates the extent of companies' commitment to developing their performance in three dimensions (social dimension, environmental dimension, economic dimension), and considering it as a long-term strategy that does not focus on the short-term activities of the company (Silva et al., 2021, 205). Both (Defang Ma et al., 2025) emphasize that sustainability performance is only achieved through several key aspects, namely (workers, materials, machines and equipment, methods and techniques, work environment). These elements complement the components of fishbone diagrams, highlighting the role of skilled, environmentally aware human resources and sustainable practices in supporting green transformation. The use of advanced technologies and eco-friendly materials in cleaner production enhances efficiency, reduces waste and environmental costs, and improves overall environmental performance, ultimately contributing to sustainable quality and a better working environment. (Wang et al., 2025, 104).

The operational scope of sustainability for quality may relate to reducing the levels of emissions, gases, and pollutants and their discharge through what quality control adopts with four strategies:

1. Reducing the flow of raw materials, i.e., using smaller quantities of them, depending on the quality of the raw materials.
2. Increasing defect-free products, i.e., reducing the number of defects in the product and the damage.
3. Reusing damaged materials, recovering raw materials from them, and replacing them.
4. Replacing harmful materials with other less harmful materials or replacing them with renewable (clean) materials (Xia et al., 2022, 1536).

When these mentioned management strategies are integrated, we transform into what is known as clean production, which is a continuous practice of a preventive strategy towards the environment, taking into account the production processes of products and services. The goal of clean production is to increase production quality and reduce the level of expenses while reducing risks to individuals. When looking at production practices and processes, it is impossible to ignore the role of quality control processes as an integral part (Santos et al., 2022, 379). The modern approach to sustainability by providing a comprehensive approach that combines sustainability and quality to improve quality control and analyze key quality control variables (detection methods efficiency) and analysis of sustainable development variables (efficiency, cost, energy, emissions), which allows for the identification of effective analysis and the identification of existing dependencies. The approach allows the comprehensive approach to determine the overall level of detection efficiency and to develop effective measures to improve the quality control process based on maintaining the relationship between the appropriate quality of the products offered and the services provided and the minimum environmental impact, i.e., taking measures aimed at conducting clean quality control. Therefore, the comprehensive approach based on improving quality control in the context of sustainable development fills the gaps related to strategic and operational flexibility. This approach is characterized by several features, namely:

A. Integrates quality assurance and control with environmental impact analysis..
B. Relies on statistical methods (quantitative, qualitative, and descriptive)
C. Evaluates changes across economic, environmental, and social dimensions.
D. Applicable to both production and service sectors for sustainable development..
E. Enables multi-dimensional analysis, including non-conformity detection, energy use, emissions, and cost efficiency.
F. Provides a comprehensive analysis of all control points within production processes..
(Pacana & Czerwinska, 2023, 3-7)

Researchers (Horinov & Azamatov, 2021) Sustainability is essential for improving quality by reducing waste and increasing efficiency through optimal resource utilization.

Achieving organizational success requires minimizing waste and maximizing output per unit of input.Sustainability includes multiple dimensions, each with specific roles:

Environmental sustainability: Focuses on protecting natural resources for future generations., Social sustainability: Emphasizes fair and ethical treatment of stakeholders.

Governance sustainability: Relates to building trust among stakeholders such as customers, employees, and investors (Horinov & Azamatov, 2021). Quality management systems aim to achieve organizational goals, while the Sustainable Quality Management System (SQMS) enhances quality, customer satisfaction, and productivity without compromising environmental and social requirements. It relies on appropriate structures and guiding principles aligned with quality control tools to support sustainable performance.

First: Continuous Improvement: Previous studies indicate that continuous improvement plays a vital role in enhancing total quality management and fostering a sustainable organizational culture. It improves the efficiency and effectiveness of production processes while promoting ongoing development through feedback from customers, suppliers, and employees, thereby supporting competitiveness and sustainability. (Reza et al., 2025, 2).

Second: Focusing on Customers: Organizations primarily aim to satisfy customer needs and expectations, as this is essential for survival, growth, and competitiveness in the market. Product and service quality plays a critical role in achieving customer satisfaction and maintaining a strong competitive position. Previous research highlights that total quality management (TQM) enhances customer satisfaction and organizational performance, thereby supporting sustainability and long-term growth. Studies also emphasize the importance of understanding customer behavior through market research, as well as the strong relationship between TQM practices and institutional sustainability (Abdulkadir, 2023; Olayiwola et al., 2024).

Third: Leadership: Modern leadership emphasizes responsible management by integrating sustainability, ethics, and social responsibility, moving beyond traditional approaches focused on efficiency. This shift supports sustainable quality through frameworks such as ISO 9001 and alignment with global sustainability goals (Laasch et al., 2023; Toft & Hansen, 2025).

Fourth: Innovation: Innovation is a key driver of long-term performance and competitive advantage, closely linked to corporate social responsibility and sustainability. Modern perspectives view sustainability as a dynamic and transformative force, expanding innovation beyond internal improvements to broader socio-technical and environmental systems. This evolving approach emphasizes that continuous innovation—often driven by ideas from customers, employees, and research—is essential for maintaining competitiveness and achieving sustainable development (Li & Yu, 2024; Wilke & Pyka, 2024; Wilkerson, 2025).

Fifth: Adaptation: If we do not adapt to change, we will eventually disappear. To ensure that you remain active, you must constantly evaluate yourself and identify the areas that need improvement through direct self-effort to do so. We will be able to identify the strengths and weaknesses of our institution. Afterwards, we can develop strategies for the problems that may arise and develop plans to overcome the obstacles that hinder growth and prosperity. Finally, we must communicate effectively with stakeholders, including employees, shareholders, and other external parties. (Horinov & Azamatov, 2021, 3)

Sixth: Transparency: Business transparency enhances the availability of accurate and timely information, supports stakeholder trust, and facilitates effective decision-making. It reflects an organization's commitment to openly communicating its social and environmental activities and taking responsibility for their impacts. Transparency is closely linked to sustainability, which integrates economic, social, and environmental considerations into business strategies and aligns with global initiatives such as the Sustainable Development Goals (Sanchez-Hernandez, 2019; Daniele et al., 2024; Tiwari et al., 2023).

Benefits of the Sustainable Quality Management System (SQMS)

If a company implements a sustainable quality management system and achieves success in the competitive job market, it will reap numerous benefits and advantages from applying the sustainable quality management system, as follows:

- Cost reduction, improved productivity, and enhanced product quality.
- Increased profitability, customer satisfaction, and strengthened company image.
- Improved employee morale, higher job satisfaction, and reduced turnover rates.
- Fewer complaints and faster recovery from crises.
- Enhanced reputation, improved occupational safety, and better work environment.
- Reduction of waste and operational losses.

(Horinov & Azamatov, 2021, 4-5)

Seventh: Social Responsibility: It can be defined as an integral part of companies, and social responsibility is the extent of the company's commitment to the communities it serves and the environment from which it derives its resources and its profitable activities (Sarwar, et al, 2023, 386). Climate change and environmental pollution have become a major focus in societal discourse, which calls for alternative attitudes towards business sustainability, which is represented by three dimensions (environmental - social - financial), and in return, companies are witnessing increasing international and local pressures to enhance their credibility for social responsibility, especially within the manufacturing sector (Han Xiao et al., 2024, 2).

Chapter Three: The Fieldwork Framework of the Research

Description of Study Variables and Testing of Hypotheses

This chapter clarifies the nature of the research variables, which are quality control tools and sustainable quality management, as outlined in the research and the formulation of hypotheses. To achieve this, the data was processed, starting with the initial analysis of the data related to the research variables. The researcher relied on the statistical software ((SPSS-26 to calculate the frequency, arithmetic mean, percentages, and standard deviations of the research variables and test their hypotheses. The chapter is divided as follows:

First: Description and Diagnosis of Research Variables

1. Description and Diagnosis of the Independent Variable (Quality Control Tools)

Table (1) shows the frequency distributions, arithmetic means, percentages, standard deviations, response rate, and coefficient of variation for the items related to human resources, based on the responses of the individuals in the study sample. The total number of items was (24) using a five-point Likert scale, and the sample size was (80). The following is an explanation of the individuals' responses to the variable of quality control tools as perceived by the individuals in the field.

Table (1) Frequency Distributions, Arithmetic Means, Standard Deviations, Response Rate, and Coefficient of Variation for the Level of Respondents' Perception of Quality Control Tools

V. S Response alternatives mean Standard deviation Response rate Coefficient of variation

Coefficient of variation	Response rate	Standard deviation	mean	Response alternatives										V. S
				strongly disagree		I don't agree		indifferent		AGREE		STRONGLY AGREE		
				%	N	%	N	%	N	%	N	%	N	
22.9	74	0.84793	3.7000	2.5	2	5	4	25	20	55	44	12.5	10	**X1**
23.6	71	0.84043	3.5500	0	0	15	12	22.5	18	55	44	7.5	6	**X2**
26.8	72.5	0.97273	3.6250	2.5	2	12.5	10	20	16	50	40	15	12	**X3**
26	69	0.89866	3.4500	2.5	2	12.5	10	30	24	47.5	38	7.5	6	**X4**
29.1	69	1.00505	3.4500	2.5	2	15	12	32.5	26	35	28	15	12	**X5**
24	70	0.84194	3.5000	0	0	12.5	10	35	28	42.5	34	10	8	**X6**
20.5	79	0.80975	3.9500	0	0	7.5	6	12.5	10	57.5	46	22.5	18	**X7**
25.6	74.5	0.95434	3.7250	2.5	2	7.5	6	25	20	45	36	20	16	**X8**
28.2	72.5	1.02346	3.6250	5	4	7.5	6	25	20	45	36	17.5	14	**X9**
26.9	73.5	0.99078	3.6750	2.5	2	12.5	10	17.5	14	50	40	17.5	14	**X10**
25.5	70.5	0.89972	3.5250	2.5	2	7.5	6	37.5	30	40	32	12.5	10	**X11**
21.4	78	0.83590	3.9000	0	0	7.5	6	17.5	14	52.5	42	22.5	18	**X12**
22.5	74.5	0.84156	3.7250	2.5	2	2.5	2	30	24	50	40	15	12	**X13**
27.3	77	1.05341	3.8500	15	12	20	16	22.5	18	25	20	17.5	14	**X14**
29.6	67	0.99492	3.3500	5	4	12.5	10	35	28	37.5	30	10	8	**X15**
25.8	73	0.94266	3.6500	2.5	2	10	8	22.5	18	50	40	15	12	**X16**
27.5	72.5	0.99842	3.6250	2.5	2	12.5	10	22.5	18	45	36	17.5	14	**X17**
24.4	77	0.94266	3.8500	2.5	2	5	4	22.5	18	45	36	25	20	**X18**
34.7	58.5	1.01601	2.9250	7.5	6	30	24	27.5	22	32.5	26	2.5	2	**X19**
37.8	54.5	1.03085	2.7250	12.5	10	30	24	32.5	26	22.5	18	2.5	2	**X20**
28.9	62.5	0.90533	3.1250	2.5	2	25	20	32.5	26	37.5	30	2.5	2	**X21**
36.8	61.5	1.13377	3.0750	7.5	6	25	20	32.5	26	22.5	18	12.5	10	**X22**
28.2	69.5	0.98051	3.4750	5	4	10	8	27.5	22	47.5	38	10	8	**X23**
21.5	77	0.82830	3.8500	0	0	5	4	27.5	22	45	36	22.5	18	**X24**
				3.6		**12.9**		**26.5**		**43.1**		**13.9**		**Average**
24.4	**72.5**	**0.88703**	**3.6250**	16.5						57				

1. Quality Control Tools: The data in Table (1) shows agreement among the respondents' opinions regarding the factors of this variable (X1-X24), as the average of the individuals' responses (57%) (strongly agree, agree) indicates that opinions are directed positively, and based on the five-point Likert scale, and this was reinforced by the arithmetic mean (3.6250), which is higher than the hypothetical mean of the scale, which is (3), while the degree of disagreement between the respondents' answers to the paragraphs related to this dimension reached (16.5%) (disagree, strongly disagree), and the percentage of neutral responses for individuals reached (26.5%), and this was reinforced by the value of the arithmetic mean (3.655) and the standard deviation (0.88703) and the coefficient of variation by (24.4%), and the response rate to the scale area reached (72.5%). One of the most prominent research paragraphs that contributed to enriching this variable is (7X), which states (the company encourages cases of excellence in using the quality control maps tool and makes them an example for others to follow), it came with an agreement rate of (57.5%) and an arithmetic mean of (3.9500) and a standard deviation (0.95434) and a response rate of (74.5%), and the least contributing paragraph is (20X), which states that (we support the

performance evaluation process to achieve sustainable self-growth), the agreement rate is (22.5%) and the arithmetic mean is (2.7250), and the standard deviation is (1.03085) and the response rate is (54.5%), and the rest of the research paragraphs obtained agreement rates between these two ratios.

Description and Diagnosis of the Dependent Variable (Sustainable Quality Management) Table (2) presents the frequency distribution, arithmetic mean, percentages, standard deviations, response rate, and coefficient of variation for the items related to sustainable quality management, based on the responses of the individuals in the research sample. The total number of items is (15) items, using a five-point Likert scale. The sample size is (80). The following is a description of the responses of the individuals surveyed on the variable of sustainable quality management as perceived by the individuals surveyed in the research field. Table (2) Frequency Distributions, Arithmetic Means, Standard Deviations, Response Rate, and Coefficient of Variation for the Level of Awareness of the Respondents Regarding Sustainable Quality.

V. S Response alternatives mean Standard deviation Response rate Coefficient of variation

Coefficient of variation	Response rate	Standard deviation	mean	Response alternatives										V. S
				strongly disagree		I don't agree		indifferent		AGREE		STRONGLY AGREE		
				%	N	%	N	%	N	%	N	%	N	
28.0	74	1.03606	3.7000	5	4	10	8	27.5	22	47.5	38	10	8	X1
28.2	69.5	0.98051	3.4750	5	4	10	8	27.5	22	47.5	38	10	8	X2
26.3	68	0.89443	3.4000	2.5	2	12.5	10	35	28	42.5	34	7.5	6	X3
32.2	65	1.04941	3.2500	5	4	20	16	30	24	35	28	10	8	X4
26.1	72.5	0.94635	3.6250	2.5	2	10	8	25	20	47.5	38	15	12	X5
20.2	75.5	0.76266	3.7750	0	0	5	4	27.5	22	52.5	42	15	12	X6
24.2	71.5	0.86822	3.5750	2.5	2	7.5	6	30	24	50	40	10	8	X7
28.9	72.5	1.04790	3.6250	5	4	7.5	6	27.5	22	40	32	20	16	X8
30.8	72.5	1.11803	3.6250	5	4	10	8	27.5	22	32.5	26	25	20	X9
31.1	72	1.12058	3.6000	7.5	6	7.5	6	22.5	18	42.5	34	20	16	X10
29.5	72.5	1.07179	3.6250	5	4	10	8	22.5	18	42.5	34	20	16	X11
28.6	75	1.07327	3.7500	5	4	7.5	6	20	16	42.5	34	25	20	X12
28.6	69.1	0.99010	3.4562	4.1		9.8		26.9		43.6		15.6		Average
				13.9						59.2				

2. Sustainable Quality Management:The data from Table (2) indicates agreement among the respondents' opinions regarding the items (X1-X12). The average of the individuals' responses reached (59.2%) (strongly agree, agree), meaning that the opinions of the respondents appeared positive. This is supported by the arithmetic mean (3.4562), which is higher than the hypothetical mean of the scale, which is (3). Meanwhile, the degree of disagreement in the respondents' answers to the items of this dimension reached (13.9%) (disagree, strongly disagree), while the percentage of neutral responses from individuals reached (26.9%). This is reinforced by the value of the arithmetic mean (3), with a standard deviation of (0.99010) and a coefficient of variation of (28.6%). The response rate to the scale area reached (69.1%). Among the most prominent items that contributed to enriching this variable is (6X), which states (Sustainable quality management increases the productivity of the working individual) with an agreement rate of (52.5%), an

arithmetic mean of (3.7750), a standard deviation of (0.76266), and a response rate of (79.3%). The least contributing item is (X9), which states (The process of controlling the raw material is one of the basics of the sustainable quality management system), with an agreement rate of (32.5%), an arithmetic mean of (3.6250), a standard deviation of (1.11803), and a response rate of (72.5%). The remaining items obtained agreement rates between these two percentages.

Chapter Four: Conclusions and Recommendations

First: Conclusions

1. It was shown through the results of the descriptive analysis of the seven quality control tools that there is an availability of research variables within the investigated factory, as each of the seven quality control tools and sustainable quality management obtained very good agreement rates.
2. The factory's support for the process of comprehensive control evaluation for all stages and activities in order to achieve effective control in controlling the quality of raw materials obtained the lowest agreement rate.
3. It was shown from the results of the analysis, with a very low agreement rate, regarding the extent of the factory's reliance on effective mechanisms in the selection and sampling process.
4. It became clear, with the lowest agreement rate, towards the paragraph related to the calibration of the devices used in the examinations and the determination of the level of defects.
5. It was shown with very high agreement regarding the use of control charts according to the histogram due to the ease of counting and statistical inventory, which helps them in extracting statistics as quickly as possible..

Secondly: Proposals

In continuation of the research study requirements and based on the conclusions reached, we present some proposals that the researchers consider necessary, which are as follows:

1. The need for the researched factory to pay more attention to making more effort in order to ensure the sustainability of the tools, equipment, and laboratories used in the quality assurance and quality control unit.
2. Increasing the company's serious interest in using all-encompassing control and following various methods in statistical inventory and preparing the necessary specifications and standards according to the nature of the raw materials entering each product.
3. Defining a set of policies and procedures to enhance performance in the researched factory within the quality assurance and quality control unit.
4. The factory under study must support the performance evaluation process to control quality to achieve sustainable performance.
5. The necessity of dealing with the working individuals with a high spirit within collective work teams, which is the highest principles of quality management systems, working as one team.

References:

1. Abdella, G.M., Kutty, A.A. and Kucukvar, M. (2021). An integrated sustainable quality management framework for quality-related research. Proceedings of the International Conference on Industrial Engineering and Operations Management, Sao Paulo, Brazil, 5–8 April.

2. Abdulkadir, K. (2023). Total quality management as an effective tool for achieving customer satisfaction, patronage, productivity gains and sustainability in organizations. Studies in Economics and Business Relations.
3. Al Mardawi, G.H. and Rajendram, R. (2021). Investigation of medication safety incidents using root cause analysis and action. Global Journal on Quality and Safety in Healthcare, 4, pp. 50–52.
4. Antony, J., McDermott, O. and Sony, M. (2022). The use and application of Ishikawa's seven basic tools in European organisations. International Journal for Quality Research, 16(4), pp. 1071–1082.
5. Babu, S. and Girish, B.S. (2025). Neighbourhood search-based metaheuristics for bi-objective Pareto optimization. Operations Research Perspectives.
6. Cai, W. et al. (2022). A review on methods of energy performance improvement towards sustainable manufacturing. Renewable and Sustainable Energy Reviews, 159.
7. Čabaníková, L. et al. (2025). Pareto analysis of the failure rate of passenger railway wagons.
8. Daffern, C. (2024). Standard operating procedure 19: Quality control. University of Warwick.
9. Demirkaya, F. (2022). The quality control tools used for sustainability of quality. Archives of Engineering Knowledge, 7(1), pp. 21–26.
10. Diaz Reza, J.R. et al. (2025). Achieving strategic goals by continuous improvement and lean manufacturing implementation. Sustainable Futures, 9.
11. Fonseca, L., Amaral, A. and Oliveira, J. (2021). Quality 4.0: The EFQM 2020 model and industry 4.0 relationships. Sustainability, 13.
12. Giordino, D. et al. (2024). Institutional investors ownership concentration and its effect on disclosure and transparency.
13. Grigoryan, E. and Golubkova, I. (2020). Seven tools for quality management and control: Theory and practice. Advances in Economics, Business and Management Research, 139.
14. Gupta, S.N. et al. (2021). A review: Quality control. International Journal of Creative Research Thoughts, 9(1).
15. Ingaldi, M. and Ulewicz, R. (2020). Problems with the implementation of Industry 4.0 in SMEs. Sustainability, 12.
16. Ishak, A. et al. (2020). Analysis roofing quality control using statistical quality control (SQC).
17. Jaware, A. et al. (2018). Seven quality tools: A review. International Research Journal of Engineering and Technology, 5(5).
18. Karuppiah, K., Sankaranarayanan, B. and Lo, H.-W. (2024). A systematic literature review on sustainable manufacturing practices. Clean Engineering and Technology, 22.
19. Kumah, A. et al. (2023). Cause-and-effect (fishbone) diagram: A tool for generating and organizing quality improvement ideas. Global Journal on Quality and Safety in Healthcare.
20. Lasch, O., Doomsayer, D.C. and Antonopoulos, E.P. (2023). Responsible management competence framework. Journal of Business Ethics, 187(2), pp. 733–757.
21. Lee, M.G., Chechurin, L. and Lenyashin, V. (2018). Cause-effect chain analysis in manufacturing problems. International Journal of Advanced Manufacturing Technology, 99, pp. 2159–2169.
22. Leong, T.K. and Zakuan, N. (2014). Review of quality management system research. International Journal of Productivity and Quality Management, 13(1).
23. Li, C. and Yu, Q. (2024). Sustainability-oriented social responsibility and corporate innovation.
24. Magar, V.M. and Shinde, V.B. (2014). Application of 7 QC tools for continuous improvement. International Journal of Engineering Research and General Science, 2(4).
25. Mandapaka, S. et al. (2023). Application of automated quality control in smart factories. IEEE International Systems Conference Proceedings.
26. Markulík, Š., Turisová, R. and Vrabeľová, A. (2022). Quality management. Košice: Willcom.

27. Mitra, A. (2019). Fundamentals of quality control and improvement. 4th ed. Wiley.
28. Morais, R., Bulhoes, T. and Subramanian, A. (2024). Scheduling problem optimization. European Journal of Operational Research, 315, pp. 442–453.
29. NHS England (2023). Histogram tool. Available online.
30. Nissen, S.Ø. (2025). Forces of responsible leadership. International Journal of Management Education.
31. Neyestani, B. (2017). Seven basic tools of quality control.
32. Olayiwola, R.K. et al. (2024). Impact of total quality management on cleaning companies.
33. Rohkohl, E. et al. (2023). Multi-criteria real-time control using deep learning. Advanced Industrial Manufacturing Engineering, 6.
34. Salah, H. et al. (2025). Sustainability-driven optimization of np chart. Cleaner Engineering and Technology, 26.
35. Saniuk, S., Grabowska, S. and Gajdzik, B. (2020). Social expectations and Industry 4.0. Sustainability, 12.
36. Santos, V.H.D. et al. (2022). Towards a green industry. Environmental Science and Pollution Research, 29.
37. Sinha, A.K. and Vatsa, R. (2022). Control charts and capability analysis for SPC.
38. Teplická, K. et al. (2021). Evaluation of mining processes. Processes, 9.
39. Tiwari, M. et al. (2023). Corporate social responsibility and supply chain. International Journal of Finance & Economics, 28.
40. Toft, K.H. and Hansen, M.B. (2025). Sustainability discourses in leadership literature. Business Strategy and the Environment, 34(2).
41. Trout, J. (2023). Fishbone diagram: Determining cause and effect. Available online.
42. Verma, P. (2020). Quality control: A review. Journal of Medical Science and Technology, 9(1).
43. Wang, H. et al. (2025). Digital finance and enterprise productivity. International Review of Financial Analysis, 104.
44. Wilke, U. and Pyka, A. (2024). Knowledge exchange in sustainability innovation networks. Sustainability Science, 19(4).
45. Wilkerson, B. (2025). Advancing sustainability-oriented innovation practice.
46. Xia, L.T. and Lin, X.M. (2022). Sustainable product design. Journal of Environmental Protection and Ecology, 23.
47. Yazdani, M. and Haghani, M. (2024). Evolution of machine scheduling. Engineering Applications of Artificial Intelligence, 133.