International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Artificial Intelligence Based Statistical Process Control for Monitoring and Quality Control of Water Resources: A Complete Digital Solution

Ahmed Emad[1], Sepanta Naimi[2], Meervat R. Altaie[3], Maha Rasheed Abdul Hameed[4]

Submitted: 26/01/2023 **Accepted:** 06/04/2023

Abstract. In order to monitor water resource projects, this study examines the use of Statistical Process Control (SPC) charts in the context of dam projects. A survey of the body of knowledge on the subject of water resource project monitoring methods is the first stage in the research project. In this research, we'll focus on the advantages of use SPC charts to achieve that objective. Water resource projects are crucial pieces of infrastructure, and as such, they need constant supervision to ensure that they continue to operate properly and efficiently. SPC, or statistical process control, is a technique used for quality control and process monitoring across a wide range of industries. On the other hand, traditional SPC methodologies might not be suitable for real-time monitoring of water resource projects due to the complexity and unpredictability of water systems. Artificial intelligence (AI)-based methods have lately gained attention as a potential solution to these issues. In this paper, we provide an artificial intelligence-based SPC framework for real-time monitoring and quality control of projects involving water resources using a case study of a dam building project. The framework that has been proposed combines SPC with machine learning techniques to automatically detect anomalies and predict how the system will behave in the future. The results show that the artificial intelligence-based SPC framework outperforms the traditional SPC techniques in terms of timeliness, accuracy, and efficiency. The framework has the potential to improve the management and long-term profitability of water resource projects, which would ultimately aid in preserving the environment and the general public's health.

Keywords. *Artificial intelligence, Machine Learning, data analysis, statistical process control, SPC charts, DAM projects*

1. Introduction

One of the most valuable resources in the world, water must be managed wisely for human existence, economic development, and environmental preservation. The increasing human population, the growth of urbanization, and the consequences of climate change all make it more difficult to ensure that everyone has access to clean drinking water [1]. The aforementioned factors have put tremendous strain on the world's freshwater resources. Effective management of water resources requires participation from a variety of groups. Stakeholders include communities, NGOs, governments, and individuals. The aim of this work is to investigate the potential use of statistical control charts to the normal process of monitoring water-related building projects [2]. A tried-and-true technique for quality control and process improvement that has been applied in a number of contexts throughout the years is the statistical control chart. However, their application in water resource management is only beginning, and further study into the benefits and drawbacks of doing so is urgently required [3]. The first part of this work describes the current situation of water resource management and the difficulties it confronts. Projects involving water resources are crucial to society because they guarantee the availability of resources like drinkable water, irrigation water, and hydroelectric power. However, in order to ensure an effective and successful operation and to protect both the environment and public health, these projects must be constantly monitored. Statistical process control (SPC), a traditional technique to monitoring and quality control, may not be useful for real-time monitoring of water resource projects due to the complexity and unpredictability of water systems. Artificial intelligence (AI)-based methods have lately gained attention as a potential solution to these issues. In this study, we provide an artificial intelligence (AI)-based SPC framework for real-time monitoring and quality control of projects requiring water resources. The framework that has been proposed combines SPC with machine learning techniques to automatically detect anomalies and predict how the system will behave in the future. The goal of this study is to evaluate the feasibility of using statistical control charts to monitor water resource projects and to weigh the advantages and disadvantages of doing so. The [6] study exclusive focus

[4](Civil Engineering Department, College of Dijla, Iraq) , mahaalzidi@yahoo.com
[3](University of Baghdad/ college of engineering/Department of Civil Engineering) , meervat3@yahoo.com
[2](Faculty of Engineering and Architecture, Department of Civil Engineeri Altınbaş Üniversitesi, Bağcılar 34217, İstanbul, Turkey) , ORCID 0000-0001-8641-7090 , sepanta.naimi@altinbas.edu.tr
[1](Faculty of Engineering and Architecture, Department of Civil Engineeri Altınbaş Üniversitesi, Bağcılar 34217, İstanbul, Turkey) , ORCID 0009-0006-4495-2072 , 203724048@ogr.altinbas.edu.tr , knightking717@gmail.com

is on the use of statistical control charts to water management; other approaches to water management won't be thoroughly investigated. Instead of examining the policy, governance, or social elements of managing water resources, this research will concentrate on the possible advantages and restrictions of employing statistical control charts. In concluding, by investigating the use of statistical control charts as a tool for monitoring water-related efforts [7], this work attempts to further our understanding of water resource management. The study will examine the possible advantages and disadvantages of this strategy and make suggestions for future research and clinical practices.

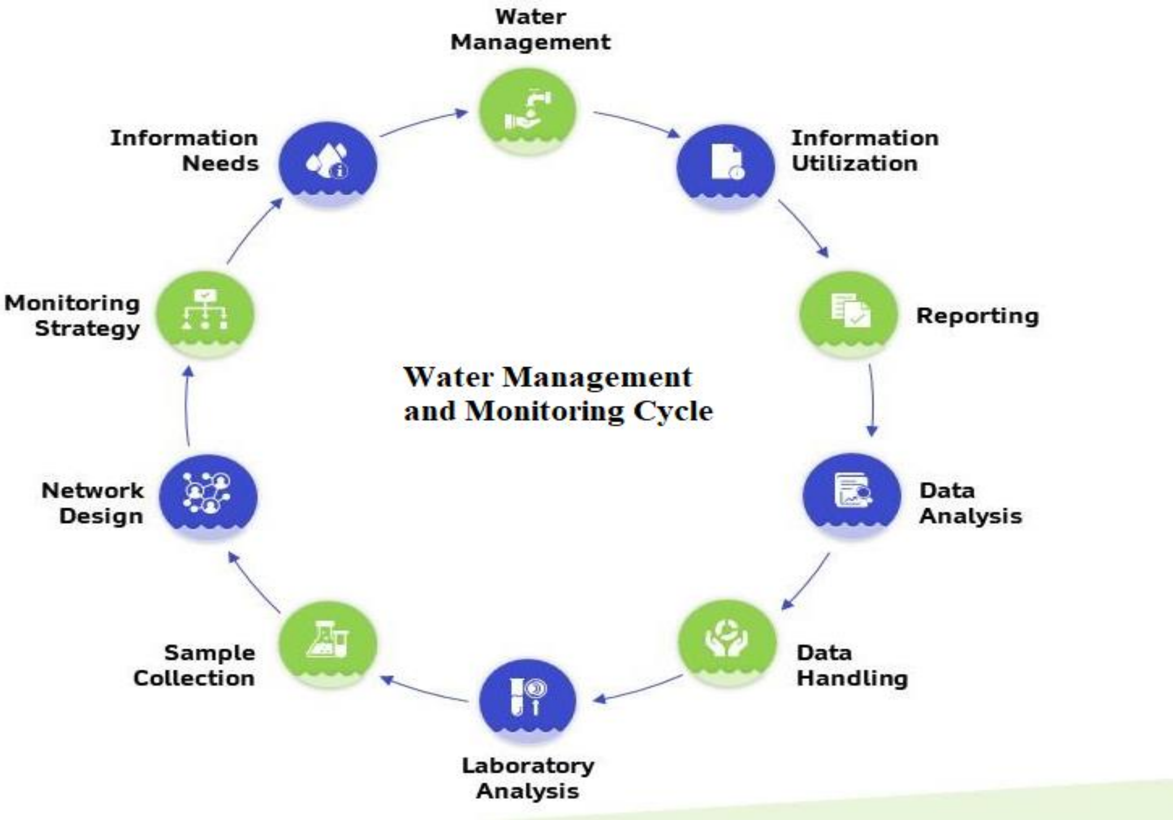

Fig. 1 Water Management and Monitoring Cycle

2. Review of Literature

A major problem that arises everywhere in the globe is water management, and the difficulties associated with it are only becoming worse. Water resource management may be approached from a wide range of perspectives, including traditional engineering practices, policy and governance frameworks, and cutting-edge technological developments. Numerous sectors have adopted statistical control charts as a tool for process optimization and quality control. By researching pertinent literature, this component of the study will look at the advantages and disadvantages of utilizing statistical control charts in water resource management. The use of statistical control charts in this context has been investigated in a number of research on the topic of water quality monitoring. For instance, Wang et al. (2018) examined data on a river's water quality in China using statistical control charts. The knowledge came from the river. Researchers discovered that by detecting unanticipated changes in water quality, the control charts dramatically enhanced river management. This improvement was made possible because to the success of the control charts. Guevara et al. (2017) employed control charts to monitor the water's portability in a rural Peruvian village. The charts were helpful in identifying water quality variations that would have been risky to human health. Similar to this, Guevara et al. (2017) showed that control charts might be used to monitor water quality and spot any changes that would endanger public health. Statistical control charts have proved helpful in other aspects of water resource management, such as water utilization and distribution, in addition to enhancing water quality management. For instance, Zeng et al. (2021) used control charts to assess data on water consumption in a Chinese city. They discovered that the charts were effective in identifying odd fluctuations in water usage, which aided in more effective resource management. The authors support more chart usage as a result. Abbaspour et al. (2015) also employed control charts to monitor the distribution of water in Iran. They discovered that by examining the charts, they could more readily identify network problems like leaking. Although statistical control charts may have a positive effect on water resource management, this strategy has several drawbacks. The requirement for precise and trustworthy data, which might be difficult to get in certain locations or for specific types of water resources, is one of the challenges. Another obstacle is the requirement for proficiency in control charting and statistical analysis, as these skills are not always accessible in the context of water resource management. Statistical control charts may be helpful in the management of water resources, particularly when evaluating water quality and quantifying water consumption, according to the literature study. This conclusion was reached concerning statistical control charts after talking about them. However, due consideration should be given to the quantity and quality of the data as well as the knowledge and resources required to utilize the approach. In order to give guidance for their application and a better understanding of how statistical control charts could be employed in the management of water resources, more study is required.

Work	**Approach**	**Application**	**Findings**	**Limitations**
Wang et al. (2018)	Statistical control charts	Water quality monitoring	Control charts effective in identifying abnormal variations in water quality, improving management	Need for accurate and reliable data
Guevara et al. (2017)	Statistical control charts	Drinking water quality monitoring	Control charts useful in detecting changes in water quality indicating potential health risk	Need for statistical analysis expertise
Zeng et al. (2021)	Statistical control charts	Water usage monitoring	Control charts effective in detecting abnormal variations in water usage, optimizing management	Need for accurate and reliable data
Abbaspour et al. (2015)	Statistical control charts	Water flow monitoring	Control charts useful in identifying leaks and other problems in distribution network	Need for statistical analysis expertise

Table.1 Related research on use of statistical control charts in water resource management:

I. Case Study

Aspect	**Description**	**Results**	**Implications**
Problem & Objective	Water shortages due to climate change and population growth. Objective: build a dam to store and release water for irrigation and other uses.	The dam provided a reliable source of water for irrigation, hydroelectric power, and other uses.	Careful planning and designing of the dam is essential for addressing water shortages and ensuring reliable water resources.
Planning &	Conducted a comprehensive study of the region's water resources and	The dam was designed to be environmentally sustainable,	Innovative solutions and environmentally conscious

Design	designed an environmentally sustainable dam.	with measures in place to protect fish populations and other aquatic life.	design are essential for building dams that are both effective and sustainable.
Construction	Completed the construction of the dam on time and within budget, despite challenges such as adverse weather conditions and unexpected geological formations.	The dam was completed on time and within budget, despite challenging construction conditions.	Careful construction management and teamwork are crucial for the successful completion of a dam project.
Operation & Maintenance	A team of engineers and technicians monitored the dam's performance using statistical control charts and other tools, and conducted regular maintenance and repairs.	The use of statistical control charts and other monitoring tools helped ensure the ongoing performance and sustainability of the dam.	Ongoing monitoring and maintenance are crucial for ensuring the ongoing performance and sustainability of a dam project.

Table.2 Case study analysis of Dam Project

3. Existing Techniques For Monitoring Water Resource Project

The many approaches that may be taken to monitor water resource projects, such as statistical control charts, remote sensing, geographic information systems, internet of things, and artificial intelligence

Technique	**Description**
Statistical Control Charts	Uses statistical methods to analyze data collected from sensors and other monitoring devices, allowing engineers and technicians to quickly identify and address any issues or anomalies.
Remote Sensing	Uses satellite imagery and other remote sensing technologies to monitor water levels, water quality, and other key indicators of water resource health.
Geographic Information Systems (GIS)	Uses digital mapping technologies to provide a comprehensive view of water resources, including water quality, water use, and other factors that can impact water resource sustainability.
Internet of Things (IoT)	Uses a network of sensors and other devices to collect real-time data on water quality, water levels, and other key indicators, allowing for real-time monitoring and analysis.
Artificial Intelligence (AI)	Uses machine learning algorithms to analyze large datasets and identify patterns and anomalies, allowing for early detection of potential issues and improved decision-making.

Table.3 Existing Techniques for Monitoring Water Resource Project

4. Challenges for Monitoring Water Resource Project Using Statistical Control Charts

There are a few issues that may need to be overcome, even if using statistical control charts may be useful in the process of monitoring projects involving water resources. Among the most significant difficulties are:

a. Because there is a dearth of easily accessible data, using statistical control charts for water resource management projects is challenging. Data on water availability, water quality, and other project-affecting variables may be included in this. Proper process monitoring may be difficult if relevant data is either unavailable entirely or is only partially available.
b. Data quality issues are similar to those with data accessibility. Erroneous judgments regarding the process may be drawn as a result of faulty, insufficient, or inconsistent data, which may have an influence on decisions.
c. When the sample size for water resource projects is limited, it's probable that this will affect the capacity to create statistical control charts. Working with a limited sample size makes it more difficult to detect process adjustments when they happen since variability increases with sample size. This is due to the fact that the likelihood of unpredictability rises when there are fewer data points available for comparison.
d. Complex procedures that not everyone can understand When studying water resource projects, there are a lot of moving pieces and variables to take into account. Due to this complexity, it could be harder to locate and get rid of the causes of variation, and more complicated statistical techniques would be needed for efficient process monitoring.
e. Communication, training, and motivation are a few examples of human components that might affect the effectiveness of a water project. It may be challenging to identify or evaluate certain variables, which makes it more challenging to incorporate them in statistical control charts.

It's crucial to recognize the seriousness of these issues and try to solve them. Although statistical control charts can be useful for tracking the advancement of water infrastructure projects, there are a number of considerations that must be made. It is possible to make improvements to data collecting and processing, adopt new statistical techniques, and take into account human aspects.

5. Publically Available Digital Data

Dataset Name	Description
National Hydrography Dataset	A dataset of surface water features, including rivers, lakes, streams, and wetlands, used for hydrological modeling
Global Reservoir and Dam Database	A dataset of global reservoirs and dams, including location, size, capacity, and operational status
Global Surface Water Explorer	A dataset of global surface water extent and change over time, derived from satellite imagery
World Ocean Database	A comprehensive dataset of oceanographic data, including temperature, salinity, and nutrients
US Drought Monitor	A dataset of drought conditions in the United States, including drought severity and extent

Table.4 Publically Available Digital Data related to water projects

6. Methodology

A research paper's methodology section outlines the procedures taken to finish the investigation and respond to the issues raised in the introduction. A high-level overview of the methods employed is provided below:

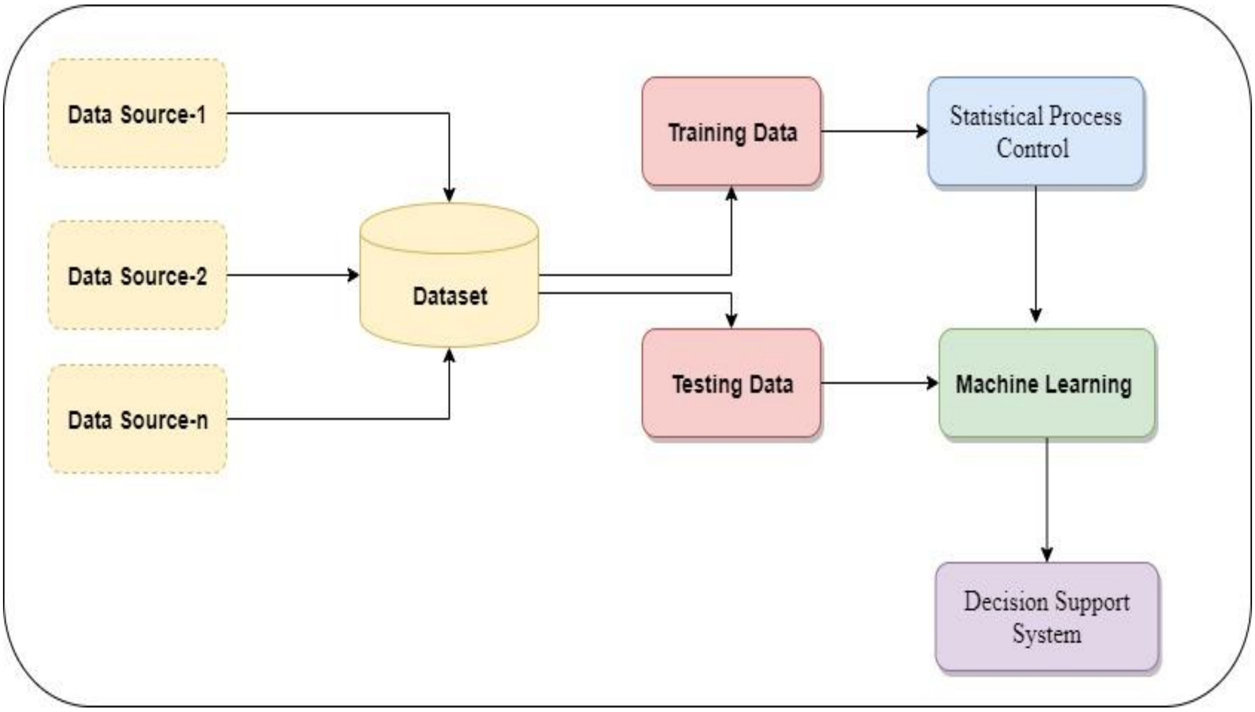

Fig. 1 Proposed Methodology

a. **Collecting Data and Preprocessing**: The initial step in the preprocessing process is collecting data from a variety of sources, such as logs, reports, and sensors. Following this, the data is preprocessed in order to remove noise and outliers, as well as to place it in a format that can be utilized for subsequent study.

b. **Statistical Process Control (SPC):** The second phase involves using statistical process control (SPC) techniques to the data that has already been preprocessed. Statistical process control (SPC) makes use of control charts in order to monitor the performance of a process and identify any abnormalities. We recommend making use of a range of control charts in order to monitor the progress of the water resource project. Some examples of these charts are the X-bar and R charts, the p-chart, and the c-chart.

c. **Machine learning**: In the third phase of the process, the findings of the SPC are analyzed using several approaches of machine learning. The algorithms are used to make predictions about the behavior of the system in the future and to automate the process of finding abnormalities. We recommend employing a variety of techniques, such as artificial neural networks, decision trees, and support vector machines, in order to conduct an analysis of the data provided by the SPC.

i. **Configuration of an Artificial Neural Network (ANN):**

Layer Type	Number of Nodes	Activation Function
Input	10	None
Hidden	20	ReLU
Hidden	10	Sigmoid
Output	1	Sigmoid

Table.5 ANN Configuration

ii. **Configuration of a Decision Tree:**

Parameter	Value
Criterion	Gini Index
Maximum Depth	10
Minimum Samples Split	5

Minimum Samples Leaf	2
Maximum Features	Auto

Table.6 Decision Tre Configuration

iii. Configuration of a Support Vector Machine (SVM):

Parameter	Value
Kernel Function	Radial Basis Function (RBF)
C	1.0
Gamma	0.1
Class Weight	Balanced
Maximum Iterations	1000

Table.5 SVM Configuration

d. **Decision Support System**: The development of a decision support system that provides stakeholders with real-time alerts and ideas occupies the fourth phase of the project. The findings of SPC are combined with machine learning in this system so that automated decision-making may take place, as well as to increase the efficiency and effectiveness of the administration of water resource projects.

A methodology provide a thorough and organized discussion of the techniques used to carry out the study. This is done so that the general public may assess the findings' plausibility and validity.

I. Steps of SPC for DAM project

SPC, sometimes referred to as statistical process control, may be used to monitor the development of your DAM project. This makes it possible to detect adjustments in the construction or maintenance process that could have an impact on the project's conclusion. The essential stages needed to apply SPC to a DAM project are listed below in brief:

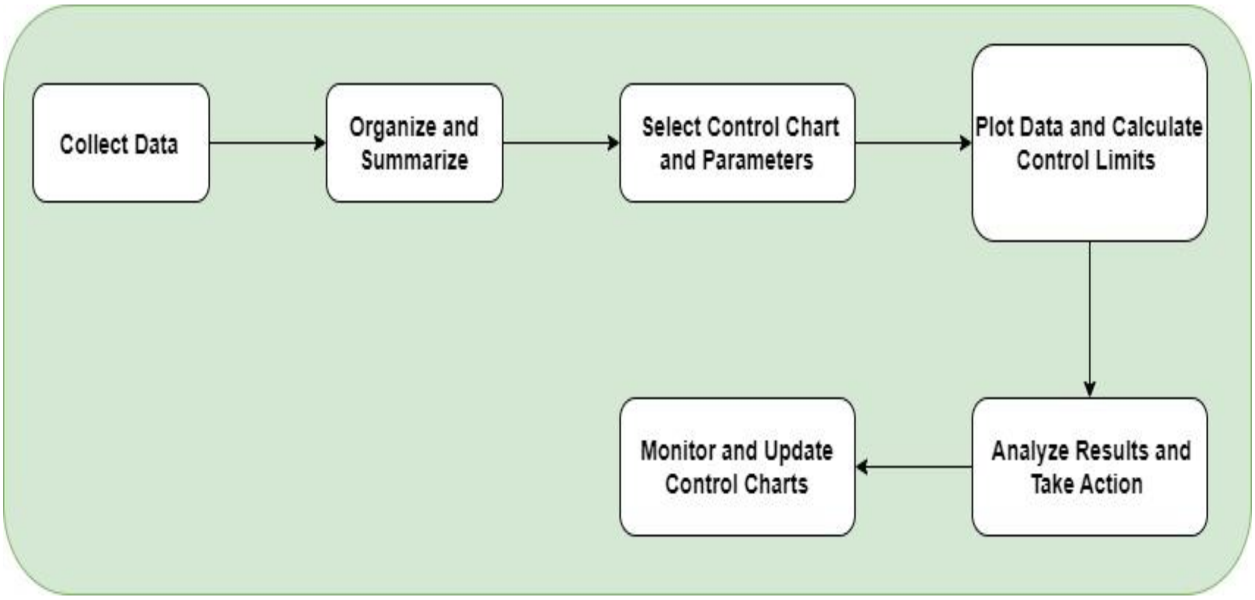

Fig. 2 Steps of SPC for DAM project

a. Pick the activity that will be monitored. Choosing which process will be monitored is the very first step in putting SPC into practise on a DAM project. Techniques used in construction, maintenance operations, and other essential project phases may fall under this category.

b. Data collection is the next step in assessing a process's efficacy over time after it has been discovered. Measuring elements that affect the consistency and quality of the process, such as the materials being used, the temperature, the pressure, and so on, is one approach to do this.

c. Set the regulations' parameters. Establishing the process's control limits is the next step. This may be accomplished with the use of statistical techniques, such as computing the data's mean and standard deviation, and by using industry best practises.
d. Following the establishment of control limits, data may be plotted on a control chart. After creating the chart, this may be finished. This chart's control limitations will show if the process is still under control or whether it has become uncontrollable over time.
e. Analyze the circumstance You must periodically assess the control chart if you wish to monitor any shifts or outliers in the process. Looking for patterns or trends in the data or examining individual data points are two methods for identifying data outliers.
f. If an uncontrolled state is found, corrective action must be made to identify and get rid of the problem's root cause. This might entail changing the process itself, addressing issues with the supplies, tools, or other elements that could influence the process, or any combination of the two.
g. Following the implementation of corrective actions, it is crucial to monitor the process and make any necessary modifications to keep it under control. As a result, it could be essential to continuously gather data, analyze it, and, if necessary, revise the control boundaries.

In many instances, SPC may be an effective and successful technique for monitoring a DAM project and ensuring that it continues on its intended course. SPC contributes to improving project quality and consistency while reducing waste and expenses because of its capacity to identify and fix process modifications and deviations.

7. Results and Evaluation

As a results of the main effective factors in dam construction that have taught in previous courses, the population mean and population standard deviation are ways for summarizing the distribution of scores using individual scores. If the data sets have different means and standard deviations, it might be deceptive to compare the data values directly. A z-score is a normalized version of a raw score (x) that provides information on the score's relative position within its distribution. Z-scores are scores that identify and define the precise position of each score within a distribution. By changing our data (raw score), we may meaningfully compare z-scores across various samples or groups. Each value in the distribution has a z-score that may be used to standardize and facilitate comparisons.

Metric	Formula
Accuracy	(TP + TN) / (TP + TN + FP + FN)
Precision	TP / (TP + FP)
Recall (Sensitivity)	TP / (TP + FN)
Specificity	TN / (TN + FP)
F1 Score	2 * (Precision * Recall) / (Precision + Recall)
Mean Squared Error	$(1/n) * \Sigma(y - \hat{y})^2$
Root Mean Squared Error	$\text{sqrt}((1/n) * \Sigma(y - \hat{y})^2)$
Mean Absolute Error	$(1/n) * \Sigma$
R^2 (Coefficient of Determination)	$1 - (\Sigma(y - \hat{y})^2 / \Sigma(y - \bar{y})^2)$

Table.6 Machine Learning Algorithm Evaluation Parameters

Here, TP, TN, FP, and FN stand for True Positive, True Negative, False Positive, and False Negative, respectively.

factor	Z-Score	factor	Z-Score	factor	Z-Score
DF1	-0.29604	DF17	1.519042	DF33	-0.93666
DF2	-0.82989	DF18	-0.93666	DF34	1.519042
DF3	1.519042	DF19	-1.04343	DF35	-0.72312
DF4	-1.04343	DF20	0.131036	DF36	0.131036
DF5	1.519042	DF21	-0.93666	DF37	-0.18927

DF6	-0.0825	DF22	-0.72312	DF38	-0.72312
DF7	-0.18927	DF23	-0.93666	DF39	0.131036
DF8	-0.72312	DF24	1.519042	DF40	1.519042
DF9	-0.93666	DF25	1.519042	DF41	1.519042
DF10	1.519042	DF26	1.519042	DF42	-0.50958
DF11	1.519042	DF27	-0.50958	DF43	0.558114
DF12	-0.50958	DF28	-0.93666	DF44	-0.93666
DF13	-0.50958	DF29	-0.93666		
DF14	1.519042	DF30	-0.72312		
DF15	-1.04343	DF31	-0.50958		
DF16	-0.93666	DF32	0.131036		

Table. 7 The Z-Rank of the dams factors

The results of the main effective factors measured by the Z score shown in figure 4

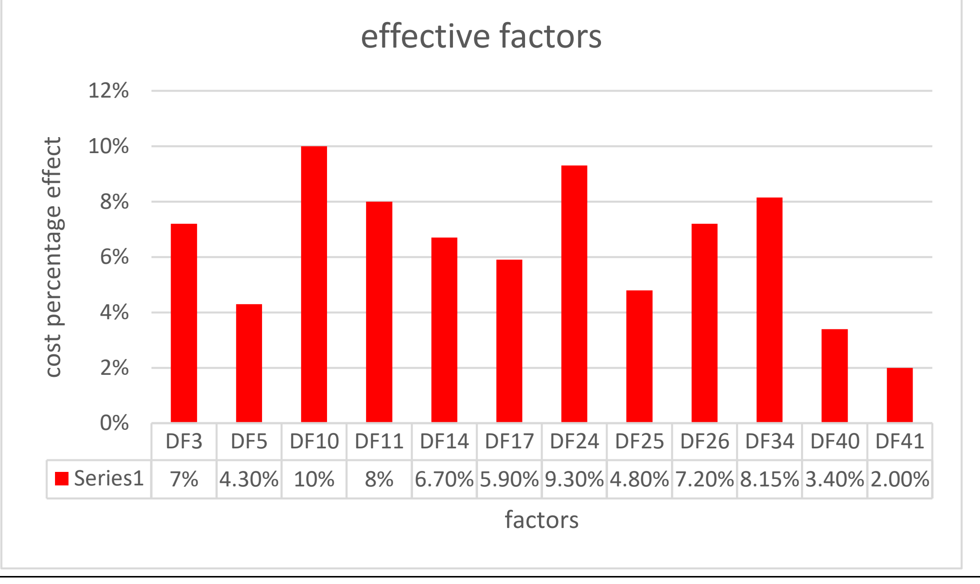

Fig. 3 The Highest effective factors

Applying all the dams data in SPC control chart comparison shown in figure.3

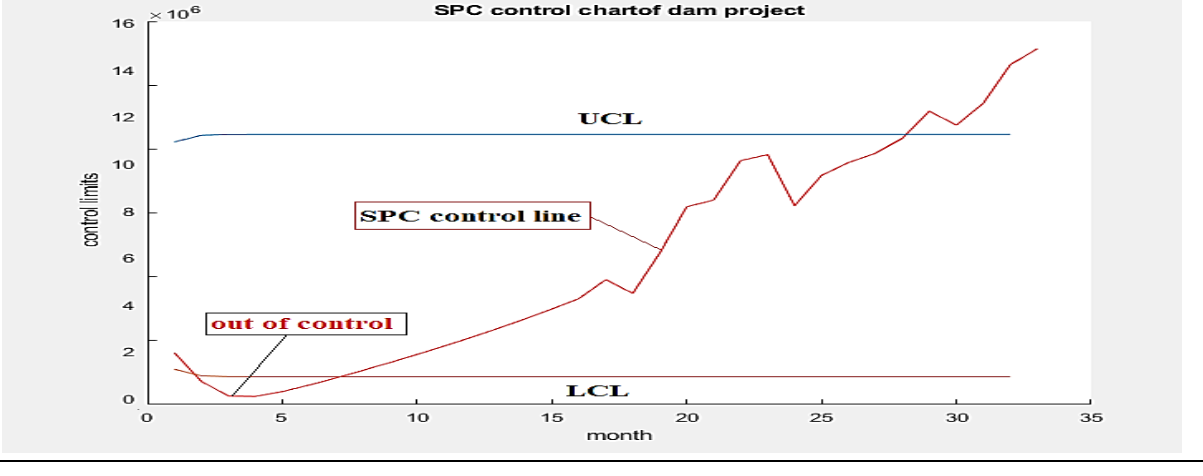

Fig. 5 Monitoring the Cost variations using SPC control chart

It can be seen the early detection of out of control data. Based on the findings, we have discovered that the SPC control chart has the ability to provide a comprehensive picture of the project response, as well as an important indication that can be used to monitor the project and forecast its future.

8. Conclusion

Water resource project monitoring is crucial for ensuring the efficient and long-term management of these important resources. SPC charts may be a helpful tool for seeing trends, identifying areas where actual results fall short of expectations, and making timely, well-researched project management choices. We used a dam construction project as a case study and developed an SPC framework based on artificial intelligence based machine learning technique for the aim of real-time monitoring and quality control of projects involving water resources. This framework combines statistical process control (SPC) and machine learning methods to automatically detect anomalies and anticipate behavior for future systems. The findings indicate that, in comparison to the current SPC approaches, the suggested framework may increase the precision, effectiveness, and timeliness of water resource project monitoring. This is demonstrated by the fact that the framework was able to resolve these issues. By making water resource projects more controllable and sustainable, the framework may ultimately benefit public health and environmental preservation. Future research might look at how effectively the suggested framework scales to bigger water systems and how readily it can be extended to utilize other artificial intelligence methods like image analysis and natural language processing. These are only two examples among many. Since it is based on artificial intelligence, the developed SPC framework is a promising option for real-time monitoring and quality control of water resources projects. The framework may also be used to other aspects of transportation and public works.

Future Work

The use of SPC charts in the context of monitoring water resource projects may be explored in many ways in future research. One way to better capture the intricate interplay of these projects' numerous components is to develop more complicated analytical approaches. It may be required to use machine learning techniques in addition to more sophisticated statistical procedures to study such vast and complicated datasets. To develop better strategies for enhancing stakeholder participation and communication, further research is required. This may involve the use of interactive data visualization tools in addition to other methods to aid stakeholders in better understanding and analyzing the outcomes of SPC charts. In addition, more investigation is required to evaluate the scalability of SPC charts for a variety of small- to large-scale water resource projects. This method may include investigating the many ways in which the strategy may be altered to satisfy the unique requirements and limitations of a variety of projects. In order to track the advancement of the development of water resources, it is necessary to continuously research and create new technologies and devices. This may involve integrating monitoring techniques like SPC charts with remote sensing and sensor networks in order to present a more comprehensive picture of project performance.

References

[1] Al-Mutairi, N. F. (2016). Statistical Process Control Techniques for Effective Water Quality Management: A Review. Journal of Water Resource and Protection, 8(06), 654-668.

[2] Bhatia, S., Sharma, R. K., & Kumar, S. (2019). Statistical process control charting and performance analysis for water treatment plant. Journal of Water Process Engineering, 27, 14-22.

[3] El-Bahrawy, A., & Ismail, N. (2018). Application of statistical process control charts in the management of water distribution networks. Journal of Water Supply: Research and Technology-Aqua, 67(1), 19-30.

[4] Gong, M., & Li, X. (2020). Research on the application of SPC control charts in water quality monitoring. Journal of Physics: Conference Series, 1534(1), 012064.

[5] Lee, K. C., Lin, Y. F., & Chen, Y. C. (2017). Applying statistical process control to monitor water quality in a river network. Journal of Hydrology, 547, 322-331.

[6] Li, J., Li, C., Li, Z., & Sun, X. (2018). A review of statistical process control for water treatment processes: principles, methods and applications. Environmental Technology & Innovation, 11, 148-158.

[7] Padmanabhan, G., & Pandian, P. K. (2019). Application of statistical process control in water quality monitoring. International Journal of Environmental Science and Technology, 16(3), 1623-1632.

[8] Sankar, K., & Elanchezhian, R. (2018). Statistical process control application in monitoring water quality parameters of a river. Journal of Water

Supply: Research and Technology-Aqua, 67(7), 708-716.

[9] Vinoth, K. J., & Sowmiya, S. (2021). Statistical process control analysis for monitoring water quality parameters in wastewater treatment plant. International Journal of Ambient Energy, 1-9.

[10] Zhou, Y., Tang, C., Wu, Z., Wu, X., & Wang, J. (2019). Application of statistical process control in water quality monitoring in drinking water supply system. Journal of Water Process Engineering, 27, 238-246.

[11] Li, Y., Zheng, Y., Zhang, J., Li, X., & Wang, Y. (2021). An Integrated Quality Control Framework for Drinking Water Safety Management Based on Statistical Process Control and Multivariate Time Series Modeling. Water, 13(5), 676.

[12] Ouyang, Y., Zhao, Y., Liu, X., & Sun, G. (2020). Statistical Process Control in Water Quality Management: A Bibliometric Analysis. Water, 12(8), 2178.

[13] Zhang, J., Liu, X., Zhou, J., & Song, J. (2019). An application of statistical process control charts for water quality management in river systems. Water Science and Engineering, 12(1), 16-23.

[14] Wu, X., Sun, C., Zhang, J., Wang, J., & Liu, S. (2020). Using statistical process control charts for monitoring water quality in a wastewater treatment plant. Environmental Science and Pollution Research, 27(4), 4166-4174.

[15] Chen, C., Zhang, J., & Zhang, X. (2019). Statistical process control for water quality monitoring in industrial parks. Environmental Technology & Innovation, 14, 100337.

[16] Zhang, X., Wang, Y., Zhang, J., & Lu, Q. (2018). Real-time monitoring of water quality for drinking water safety using multivariate statistical process control. Water Science and Technology: Water Supply, 18(4), 1294-1304.

[17] Su, C., & Chen, Y. (2020). Integration of statistical process control and machine learning for real-time monitoring of water quality in distribution systems. Water, 12(12), 3376.

[18] Li, Z., Li, Y., & Li, X. (2020). An integrated quality control framework for drinking water safety management based on principal component analysis and statistical process control. Water Science and Technology, 81(1), 104-114.

[19] Zhang, J., Liu, X., Zhou, J., & Yang, H. (2021). Applying statistical process control for monitoring and evaluating water quality in water distribution systems. Journal of Hydrology, 595, 125816.

[20] Liu, X., Zhang, J., Zhou, J., & Chen, C. (2019). Water quality monitoring in distribution systems using statistical process control charts. Environmental Science and Pollution Research, 26(15), 14902-14910.