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Multi-Criteria Analysis of Wastewater Treatment Methods: Efficiency and Cost Evaluation

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التحليل متعدد المعايير لطرق معالجة مياه الصرف الصحي: تقييم الكفاءة والتكلفة

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Abstract:
With the increasing population and the deterioration of water resources, it has become essential to adopt new strategies to achieve sustainability in the water sector. This study aims to analyze wastewater treatment methods using multi-criteria analysis to evaluate performance based on several criteria, including pollutant removal efficiency, ease of operation and maintenance, quality of treated water, economic cost, and societal acceptance. According to the methodology, a combination of approaches was adopted, including a descriptive method to describe the wastewater treatment methods and the factors affecting them, a quantitative method to collect data from previous studies, and an analytical method to analyze these data. Four main treatment methods were selected, including the following: sedimentation, a physical treatment method; coagulation and flocculation, a chemical treatment method; activated sludge and aerated lagoons, biological treatment methods; and combined methods that integrate more than one technology. The results indicated that the multi-criteria analysis of wastewater treatment methods evaluated efficiency, ease of operation, water quality, cost, and societal acceptance. Based on the efficiency criterion, combined methods achieved the highest score (10), followed by the activated sludge method (9), coagulation and flocculation (8), aerated lagoons (7), and sedimentation (6). In terms of cost, sedimentation achieved the highest score (8), followed by aerated lagoons (7) and coagulation (6), while the lowest-rated method in terms of cost was the combined methods, with a score of (4). The combined methods demonstrated optimal performance with minimal environmental impact, while physical and chemical methods were the most economical. Sedimentation emerged as the simplest option for operation and maintenance.

Keywords: Wastewater, Treatment Methods, Evaluation Indicators, Multi-Criteria Analysis.

الملخص
مع تزايد عدد السكان وتدهور الموارد المائية أصبح من الضروري تبني استراتيجيات جديدة لتحقيق الاستدامة في قطاع المياه، ومن خلال هذه الدراسة التي تهدف إلى تحليل طرق معالجة مياه الصرف الصحي باستخدام التحليل متعدد المعايير لتقييم الأداء بناءً على عدة معايير منها الكفاءة في إزالة الملوثات وسهولة التشغيل والصيانة وجودة المياه الناتجة والتكلفة الاقتصادية وقبول المجتمع؟ ووفقاً للمنهجية تم تضمين عدد من المنهجيات منها المنهج الوصفي لوصف طرق معالجة المياه والعوامل المؤثرة عليها والمنهج الكمي في جمع البيانات من الدراسات السابقة والمنهج التحليلي لتحليل هذه البيانات، حيث تم اختيار أربع معالجات رئيسية وتم اختيار الطرق التالية: الترسيب وهي إحدى الطرق الفيزيائية لمعالجة مياه الصرف الصحي وكذلك (التخثر والتكتل) وهي إحدى الطرق الكيميائية. لمعالجة مياه الصرف الصحي، وكذلك طريقة (الحمأة المنشطة وبرك التهوية) وهي إحدى الطرق البيولوجية لمعالجة مياه الصرف الصحي، وكذلك الطرق المركبة التي تجمع بين أكثر من تقنيتين. وأشارت النتائج إلى أن التحليل متعدد المعايير لطرق معالجة مياه الصرف الصحي قام بتقييم الكفاءة

وسهولة التشغيل وجودة المياه والتكلفة وقبول المجتمع. وكانت أعلى درجة حسب معيار الكفاءة هي الطرق المركبة بتقييم (10)، تليها طريقة الحمأة المنشطة (9)، ثم التخثر والتكتل (8)، ثم برك التهوية (7)، ثم الترسيب (6). ومن حيث التكلفة، حققت طريقة الترسيب أعلى درجة وهي 8، تليها طريقة التهوية بتقييم 7 ثم التخثر بتقييم 6. وكانت أقل الطرق تصنيفاً من حيث معيار التكلفة هي الطرق المركبة حيث كان تقييمها (4). وأظهرت الطرق المركبة أداءً مثالياً مع أقل تأثير بيئي، في حين كانت الطرق الفيزيائية والكيميائية هي الأكثر اقتصادية. وقد برز الترسيب كخيار أبسط للتشغيل والصيانة.

الكلمات المفتاحية: مياه الصرف الصحي، طرق المعالجة، مؤشرات التقييم، التحليل متعدد المعايير.

Introduction

In light of the increasing population increase and the deterioration of water resources and in light of the desire to achieve sustainability in the water sector, it was necessary to develop new strategies and visions that would achieve this sustainability, as sustainability in its general sense means preserving the rights of current generations without compromising the rights of future generations from environmental resources, whether Water or energy-related resources, as international reports indicate from UNICEF And the World Health Organization There are an estimated more than one billion people around the world who are deprived of water, and there are more than 3 billion people who are deprived of sanitation [1]. If we know that the world's population, according to the latest statistics, is approximately 8 billion people, we find ourselves in a situation. It is critical, as more than half of the world's population suffers from the problem of water, water resources, and sanitation. Because of these problems, diseases and deaths have spread, especially in poor regions and countries where More than 5,000 children die every day due to diarrhea and diseases related to water pollution [2]. Humans have access to fresh water, and with the development of technology, water science and research, methods of treatment for this problem may be something that is on the horizon. The horizon gives hope to millions of people to solve the problems of water resources on the surface of the planet, even if these solutions are not radical solutions. Despite the importance of water and sewage treatment methods, there are many obstacles and challenges facing these methods, including high technology costs, which have led to the exclusion of many countries, especially developing countries, from benefiting from these solutions. Also, less developed countries are trying to obtain more water resources, and at the same time, developed countries are exploiting their material and technical capabilities to solve these problems. Therefore, the real problem of study is how to achieve an optimal balance between population and water resources in all regions and in all countries and countries of the world [3]. Some solutions and proposals will also be presented that will ensure the sustainability of environmental resources and reduce environmental pollution through two main factors: reducing environmental pollution and improving water treatment methods, especially wastewater, where the choice depends. The optimal way to treat water depends on many factors, including: Efficiency, cost, environmental impact, and social acceptability. Multi-criteria analysis helps in evaluating the available options and making a decision based on comprehensive and systematic data [4].

Basic Concepts and Theoretical Background

In this part, we will try to present the basic concepts and theoretical background related to the subject of the study in a third and flexible way that contributes to forming an insightful point of view for the reader and making him understand the procedures of the study, its objectives, its methodology, and the most important results it reached, in a conscious understanding through which readers and researchers can be attracted to effective participation in achieving sustainability in the field of water. And environmental resources, whether through community participation, research participation, or even through saving Water consumption.

Basic Concepts:

Wastewater: Wastewater is water resulting from human and industrial activities that contains pollutants that make it unsuitable for direct use without treatment. These pollutants include heavy materials, including organic and inorganic materials, chemical compounds, and suspended solids, in addition to microbes and bacteria. Wastewater can be classified into main types as follows:

1) Domestic wastewater: It is water resulting from daily uses in homes, such as showering, washing, and toilets, and it contains organic materials such as fats, food residues, and microbes.
2) Industrial water: It is water resulting from the waste of various factories and often contains heavy metals and toxic chemicals in addition to thermal pollutants [5].
3) Agricultural wastewater: It is water resulting from irrigation activities and the drainage of an amount of water in excess of the soil's need. This water often contains pesticides and chemical fertilizers [6].
4) Rainwater: It is water collected as a result of rainfall, and that rain collects pollutants from roads and different areas, whether they are agricultural areas or even industrial areas.

Primary processing: The initial cycle of wastewater is the first stage in the treatment processes, through which large solid pollutants and obstacles that can hinder the following stages are removed. This stage mainly reduces organic and solid loads, which improves secondary and final treatment [7]. The initial processing takes place in a set of main steps, which are as follows:

1) Screening: where specific nets or strainers are used and with certain special basins to remove solid materials such as garbage and wood. These nets or strainers are often manual or mechanical.
2) Sand removal (Grit Removal): In this, sand is separated using special basins that are based on the idea of sedimentation due to gravity [8].
3) Primary Sedimentation: It is a process similar to the sedimentation process, where wastewater is left in large tanks so that the bulk of the heavy suspended solids settle into the bottom. These sediments are known as primary sludge [9].
4) Separation of oils and greases: Will special basins and devices be used to separate peripheral materials, such as oils and greases that float on the surface of the water, and surface tension techniques will be used?
5) Flow Equalization: Basins are used to equalize the flow of water and ensure the stability of operations in large stations, especially in areas where land levels and elevations differ from sea level[10].
6) Usually, the main outputs of this stage are primary heat and partially treated water that is transferred to the next stages of secondary treatment. The importance of this stage is due to the fact that it reduces the burden on the subsequent treatment systems, improves the efficiency of removing pollutants, protects the equipment, and reduces its maintenance costs, especially in the following stages [11].

Secondary treatment: treatment Secondary wastewater is the next stage of primary treatment. In this stage, the focus is on removing biodegradable organic materials and remaining microscopic components from the primary treatment processes. It relies mainly on biological processes in which microorganisms are used to analyze these materials and heavy organic pollutants in the water. Annual treatment operations aim to remove organic pollutants such as Such as biochemical oxygen demand (BOD) and chemical oxygen demand (COD). To improve the quality of water so that it becomes suitable for drainage or reuse in some special applications such as irrigation or use as water for washing or for human use in bathrooms. The secondary processing operations take place in a set of steps as follows:

- Activated SludgeWhere oxygen is provided to stimulate the growth of certain bacteria that decompose organic materials through the mixing of wastewater with the sludge resulting from the mixing of wastewater with sludge full of microorganisms in aeration tanks. These outputs are then sent to sedimentation conditions for separation [12].
- Aerated LagoonsIn it, microorganisms are used to analyze pollutants, but for long periods of time, during which oxygen is added continuously [13].
- Biological FiltersIn it, wastewater is sprayed over a medium filled with materials such as gravel, plastic, or resinous materials that are covered with a layer of living organisms. These living organisms work to decompose the organic materials that are separated later.
- Anaerobic SystemsIt is used to treat the resulting sludge, as anaerobic bacteria decompose organic materials without the need for oxygen.

Tertiary processing: Tertiary treatment is the final stage of wastewater treatment processes. Tertiary treatment focuses on removing fine pollutants that were not eliminated in either the first or second stage. Tertiary treatment aims to improve water quality in a way that makes it suitable for various uses such as irrigation and even drinking, and in some cases. Cases after advanced treatment [15]. It also aims to eliminate microbes to ensure health safety, get rid of micro-pollutants, and remove nutrients such as nitrogen and phosphorus, which may cause water pollution and eutrophication. The tertiary treatment is carried out in a set of steps, which are as follows:

- Physical and chemical purification:
- Coagulation and Flocculation: Adding chemicals to collect and precipitate fine particles.
- Sand Filtration: Remove remaining small particles using layers of sand.
- Nutrient Removal:
- Nitrogen removal: Using biological or chemical processes to convert nitrogen into a gas that evaporates into the air.
- Phosphorus removal: By chemical precipitation using compounds such as ferric chloride.
- UV Disinfection Water is exposed to ultraviolet rays to kill harmful bacteria, viruses, and microbes [16].
- Zonation: Where ozone gas is used to disinfect water and remove unpleasant odors and fine organic materials.

- Advanced filtration It uses very advanced techniques such as:
  - Reverse Osmosis: To remove salts, heavy metals and chemical compounds.
  - Carbon Filters: To remove organic compounds and odors.
  - Removal of heavy metals Where deposition or absorption techniques are used on absorbent surfaces, characterized by certain properties, whether in terms of adsorption or surface tension [17].

The outputs and outcomes of the tertiary treatment process are high-quality water that can be used in agriculture and industry and as an alternative to drinking water after additional treatment, in addition to a group of solids and sediments that may contain metals and contaminants that we need to dispose of in a safe way. The importance of tertiary treatment is due to the fact that it improves water quality significantly. It protects the environment by reducing organic pollutants that cause serious damage to the environment, in addition to expanding its uses. Treated water reduces dependence on natural water resources, in addition to representing natural compliance with environmental standards [18].

Pollutants:

Pollutants are the substances that cause wastewater pollution and include both organic and inorganic substances, bacteria, viruses, heavy metals, wood, garbage, microbes, and viruses.

Quality indicators:

It is a set of standards and indicators through which the quality of treated water can be evaluated, such as the concentration of salts, organic materials, bacteria, and heavy metals. They are the standards that are used to evaluate the quality of treated water, such as the concentration of organic materials, bacteria, and heavy metals. Table 1 shows the most important of these indicators [19].

Table 1: Treated wastewater quality indicators.

Standard value	Description	Indicator
≤ 20 mg/L	Amount of oxygen to decompose organic matter biologically	BOD (Biochemical Oxygen Demand)
≤ 50 mg/L	Amount of oxygen to decompose organic and inorganic matter chemically	COD (Chemical Oxygen Demand)
≤ 30 mg/L	Amount of suspended solid particles in water	TSS (Suspended Solids)
≤ 10 mg/L (Nitrogen Nitrate)	Includes nitrates, nitrites, and ammonia	Nitrogen (N)
≤ 1 mg/L	Concentration of phosphorus	Phosphorus (P)
6.5 - 8.5	Level of acidity or alkalinity in water	pH (pH)
≤ 10 units/100 ml or free	Indicator of the presence of harmful microorganisms	Coliforms
≤ 500 mg/L	Amount of dissolved salts and minerals in water	TDS (Total Dissolved Solids)
≤ 10 mg/L	Concentration of oils and greases resulting from industrial and domestic activities	Oils and Greases
≤ 1 NTU	Clearance of water based on the amount of suspended particles	Turbidity
≤ 2-3 °C	Temperature difference between discharged water and natural source	Temperature

It must be taken into account that these standard values may differ according to the environmental regulations of each country, and that adherence to these indicators guarantees the discharge of high-quality and safe treated water.

Multi-criteria analysis of processing methods

Through it, the advantages and disadvantages of each wastewater treatment method can be determined, and thus the appropriate treatment method is chosen, which depends on several main factors, which are as follows:

- Quantity and quality of wastewater: The quantity and quality of wastewater varies depending on its source, which affects the treatment method. Treating water resulting from human wastewater in homes and homes differs from treating water resulting from factory waste, which often contains chemical and organic pollutants in a large proportion.

- Environmental requirements: Environments vary and their requirements differ from one place to another, which affects the level of treatment required.
- Cost: The most important items that affect the choice of the appropriate method of treatment [20].

The Most Important Treatment Methods and Techniques

In this part, the most important methods and treatment techniques will be clarified, but a simple clarification is necessary, which is that the technique is general and can be applied in more than one way. Among the most important wastewater treatment techniques are the following:

- Physical treatment: filtration and sedimentation.
- Chemical treatment: The use of chemicals to remove contaminants.
- Biological remediation: The use of microorganisms to decompose organic materials.

As for wastewater treatment methods, there are many ways to treat wastewater, some of which are common methods, some of which are more common methods, and some of which are uncommon methods. In this section, we will discuss the most important common methods of treating wastewater, which are as follows:

- Activated sludge: It is one of the most common methods and it is possible to use specific bacteria to decompose organic materials [21].
- Oxidation pools: It is also a very common method, as shallow basins are used to treat wastewater naturally.
- Biological filters: Biological filters, which are surfaces filled with beneficial bacteria, are used to purify water, whether from fine materials or even heavy materials.
- Membranes: In it, fine membranes are used to separate solid and liquid materials. These membranes have special specifications such as adsorption and absorption [22].

Criteria used to evaluate treatment methods:

There are several criteria that can be used to evaluate treatment methods, which are as follows:

- Removal efficiency: The ability of the method to remove various contaminants.
- Operation and maintenance cost: The cost of operating and maintaining the system.
- Its impact on the environment: The effect of the method on the surrounding environment.
- Space required: Space required building and operating the system.

Importance of multi-criteria analysis:

- A multi-criteria analysis of wastewater treatment methods is essential to choose the most appropriate method for each case, as it helps:
- Improve processing efficiency: It helps to choose the method that achieves the highest efficiency in removing pollutants.
- Reduce costs: Helps to choose the most economical way.
- Preserving the environment: It helps to choose the method that has the least impact on the environment.

Method and Methodology

This part will present the analysis methodology, the tools that were used, and the materials, in addition to the stages and procedures of the analysis and evaluation process, as well as presenting the applied framework of the study and its stages and procedures.

The applied framework of the study

The applied framework of the study, as shown in Figure (1), begins with defining the goal and formulating the research problem, then collecting data, then selecting the methods to be analyzed, defining and evaluating the criteria, applying a multi-criteria analysis tool, then extracting the results and conclusions, classifying the methods based on overall performance, and choosing the method based on the balance between efficiency and cost [23].

Materials and devices

- **First, the materials:**

The materials and raw materials used in conducting multi-criteria analysis are varied and include:

1) Data :

a. Previous reliable studies

b. Databases

2) Programs for analyzing samples and simulating analysis and statistical analysis processes

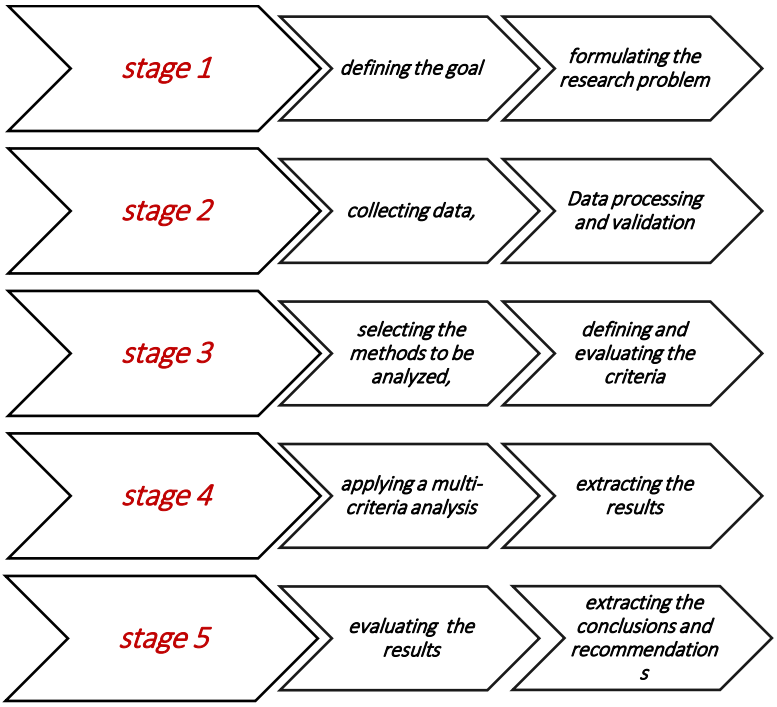

Figure 1: The applied framework of the study (by the author).

- **Secondly, the devices**

Powerful computers

Procedures:The applied procedures for the study, as previously explained through the applied framework, are as follows:

1. Defining the goal and formulating the research problem:

The aim of the study was determined, which was to conduct a multi-criteria analysis of wastewater treatment processes and compare them in terms of efficiency and cost, and choose the method that represents the balance between cost, efficiency, quality, and the impact of that method on the environment and societal acceptance.

2. Collect data and ensure its validity

The data is collected through a group of sources:

- Online databases
- Records and data of the Water, Drinking, and Sanitation Authority.
- Previous studies and major books.
- Experts and consultants

3. Choose the methods to be analyzed:

- Physical methods (eg sedimentation).
- Chemical methods (such as coagulation and sintering).
- Biological methods (eg activated sludge and aeration ponds).
- Combined methods (combine more than one technology).

4. Define standards:

- Efficiency: Percentage of removal of pollutants such as BOD, COD, and suspended solids.
- Cost: Includes initial (construction) and operational (maintenance and energy) costs.
- Environmental impact: Carbon emissions and impact on groundwater.
- Ease of operation and maintenance: The need for manpower and technical expertise.
- Community acceptance The local community accepts the proposed method [24].

5. Performance evaluation:

For each method, each criterion is evaluated using a numerical scale (e.g. 1 to 10).

6. Apply a multi-criteria analysis tool:

- Analytic Hierarchy Method (AHP): To determine the relative weight of each criterion based on priorities. Apply a multi-criteria analysis tool
  - (a) Determining the relative weight of each criterion using AHP
  - Making pairwise comparisons between criteria to determine priorities [25].

➢ **Example of relative weights:**

1) Efficiency: 40%.
2) Cost: 25%.
3) Environmental impact: 15%.
4) Ease of operation and maintenance: 10%.
5) Community acceptance: 10%.

- TOPSIS or PROMETHEE method: To rank options according to overall performance.

o Calculating overall performance using TOPSIS

o Normalization of values:

➢ Normalize the values for each criterion using the equation (1):

$$Rij=\frac{Xij}{\left(\sum_{i=1}^{m} Xij^{2}\right)^{0.5}} \quad (1)$$

Where:

Xij: is the raw performance value.

Vij: value of indicator i for alternative j.

Rij: true value of indicator i for alternative j.

Wj: relative weight of indicator j.

➢ **Calculating the distance of each alternative from the ideal solution**

The equation (2) used to calculate the distance between each alternative and the ideal solution is:

$$Di+ = sqrt(\Sigma(Vij - Vj+)^2) \quad (2)$$

Where:

- Di+: The distance between alternative i and the ideal solution.
- Vij: The value of the i parameter for alternative j.
- Vj+: The value of the j parameter in the ideal solution.

➢ Calculate the relative proximity of each option:

$$Ci = Di - /(Di + +Di-) \quad (3)$$

Where:

Di-: is the distance between alternative i and the negative solution.

Di+: is the distance between alternative i and the ideal solution

Results and discussion

It has been done Performance was evaluated according to previous literature and field experiments mentioned in wastewater treatment studies, based on the assumed values for each criterion, using a numerical scale from 1 to 10, so that:

- 1: Represents minimum performance (very poor).
- 10: Represents the highest performance (very excellent).

Table 2: Rate each method based on criteria (scale of 1 to 10).

Method	Efficiency	Cost	Environmental Impact	Ease of operation and maintenance	Community Acceptance
Sedimentation	6	8	8	9	7
Coagulation and flocculation	8	6	7	7	6
Activated sludge	9	5	5	6	6
Aeration ponds	7	7	6	8	8
Combined methods	10	4	9	5	7

According to the table 2, the highest efficiency was for the methods that were merged, as their average rating reached 10, followed in the ranking. Activated sludge, with a rating of 9, then followed in the

ranking by Coagulation and flocculation, with a rating of 8, then Aeration ponds, with a rating of 7, and finally Sedimentation comes in last place, with a rating of 6. Below is the basis on which each criterion was evaluated [26].

- **Efficiency: Efficiency depends on the rate of removal of pollutants (BOD, COD, suspended solids). For example:**
  - Biological methods (such as activated sludge) are known to be highly effective, so get 9.
  - Physical methods (such as sedimentation) are relatively less efficient, so you get 6.
- **Cost: The cost, which includes the cost, for example:**
  - Combined methods are very expensive, so get 4.
  - Physical methods are less expensive, so get 8.
- **Environmental Impact: Environmental impact measures the amount of carbon emissions and the negative impact on the environment. For example, this standard has been defined as follows:**
  - Compact and physical methods cause the least environmental impact, so get 8-9.
  - Biological methods (activated sludge) produce bioenergy but may release gases such as methane, so get 5.
- **Ease of operation and maintenance: It is a measure through which the requirements for the maintenance process and experience are determined. For example, it was evaluated as follows:**
  - Physical methods (such as sedimentation) require little maintenance, so get 9.
  - Built-in methods require high technology, so get 5.
- **Community acceptance: Where I am, community acceptance depends on when you accept the local population, for example:**
  - Physical (such as sedimentation) and biological (aeration ponds) methods are common and accepted, so get 7-8.
  - Chemical methods (such as coagulation) may face resistance due to concerns about the chemicals used, so get 6.

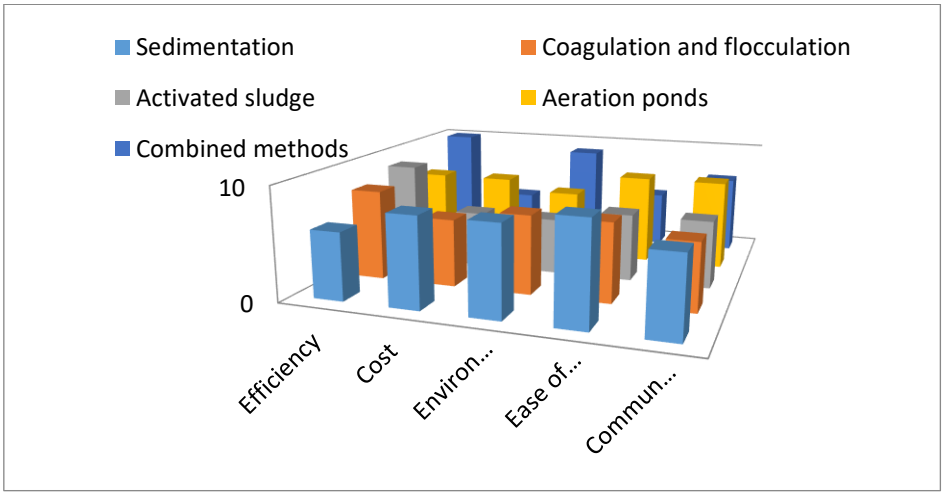

Figure 2: Multi-criteria treatment method evaluation.

According to the previous figure, the highest efficiency was for the combined methods, with an evaluation rate of 10, followed by Activated sludge with an evaluation rate of 9, then Coagulation and flocculation with an evaluation rate of 8, then Aeration ponds with an evaluation rate of 7, and finally Sedimentation comes in last place with an evaluation rate of 6.

Table 3: The values of C_i for Criterion.

Criterion	D+	D-	CI
Efficiency	9	5	0.357143
Cost	5	10	0.666667
Environmental Impact	4	9	0.692308
Ease of Operation and Maintenance	9	5	0.357143
Community Acceptance	8	6	0.428571

Environmental impact has the highest value of ci(0.692308), compared to other criteria. While, the cost has the second highest value of ci (0.666667), The efficiency, ease of operation and maintenance ci value (0.357143), and community acceptance with values of of ci (0.428571).
where:
Numerator (Di-): It represents how far the alternative is from the negative solution. The higher this value, the more it indicates that the alternative is farther away from the negative solution and closer to the ideal solution.
Denominator (Di+ + Di-): It represents the total distance between the ideal solution and the negative solution through the alternative.
Mechanism Interpretation of Ci value:
The value of Ci is close to 1: It means that the alternative is much closer to the ideal solution compared to the negative solution.
Ci value is close to 0: It means that the alternative is much closer to the negative solution compared to the ideal solution.
Ranking of options based on Ci value
After calculating the Ci value for each alternative, we rank the alternatives in descending order by Ci value. The alternative with the highest Ci value is the most appropriate, because it is closest to the ideal solution and farthest from a negative solution.
Table 4 shows the multi-criteria analysis of wastewater treatment methods according to the criteria of efficiency, ease of operation and maintenance, efficiency, water quality, cost, and societal acceptance.

- Best performance: combined methods thanks to high efficiency and minimal environmental impact.
- Best economic choice: physical or chemical methods [27].
- Easy operation and maintenance: sedimentation [28].

Table 4: Multi-criteria analysis.

Method	Efficiency	Cost	Environmental Impact	Ease of operation and maintenance	Community Acceptance
Sedimentation	2.14	5.337	5.337	3.217	3
Coagulation and flocculation	2.86	4	4.847	2.5	2.57
Activated sludge	3.21	3.337	3.467	2.147	2.57
Aeration ponds	2.5	4.67	4.157	2.86	3.43
Combined methods	3.57	2.67	6.237	1.79	3

Conclusions and Recommendations.
In this section, the most important recommendations and conclusions that were drawn during the study stages will be presented

Conclusions
Among the most important conclusions that were drawn from this study are the following:

- **General conclusions:**
  - Wastewater treatment is of great importance, especially in that it helps protect the environment by reducing pollution resulting from water discharge. It is one of the effective methods and sustainable solutions to achieve sustainability in the field of water and water resources, as by treating wastewater, water is provided to the population and protected from the spread of wastewater. Diseases resulting from drinking contaminated water and reducing the number of deaths, especially among children, in short It contributes to enhancing the sustainability of water resources.[29].
  - Standard values for evaluating treatment methods may vary according to the environmental regulations of each country. Adherence to these values and indicators ensures the discharge of treated water of high quality and is safe for human use.
  - Multi-criteria analysis provides a systematic and effective tool for making informed decisions about the best wastewater treatment methods.
- **Second, conclusions specific to the study:**
  - the highest efficiency was for the combined methods, with an evaluation rate of 10, followed by Activated sludge with an evaluation rate of 9, then Coagulation and flocculation with an

evaluation rate of 8, then Aeration ponds with an evaluation rate of 7, and finally Sedimentation comes in last place with an evaluation rate of 6. [30].

- The multi-criteria analysis of wastewater treatment methods was conducted based on the criteria of efficiency, ease of operation and maintenance, water quality, cost, and societal acceptance. The findings from the table indicate the following [31-34]:
  - Optimal Performance: Combined methods stand out due to their high efficiency and minimal environmental impact.
  - Most Economical Option: Physical or chemical methods are the most cost-effective choices.
  - Simplest in Operation and Maintenance: Sedimentation offers the greatest ease of operation and maintenance.

Recommendations

The most important recommendations that can be made are the following:

1. It must be taken into account that any method chosen for treating wastewater is compatible with the application in which the treated water is intended to be used, based on achieving a balance between efficiency and cost, taking into account long-term environmental impacts.
2. Educating the local community about the importance of treatment methods to ensure acceptance and cooperation, as most and most people do not believe in the idea of sanitary treatment of wastewater.
3. Choosing and implementing hybrid technologies to conduct wastewater treatment operations in order to benefit from the advantages of each technology and thus achieve a higher quality level, higher efficiency, and reduce the cost.
4. But for more efforts, whether they are research efforts to develop new methods for treating water, trying to reduce the cost of modern technologies, and technical applied efforts related to treatment processes.
5. Cooperation between all parties, whether governmental entities, private entities, or even members of society, in achieving Islam in the field of water and water resources in light of the terrible inability that the planet is witnessing in meeting the requirements of water resources for the increasing population.

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