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# Selection of Water Treatment Technology in the Mineral Water Industry Using the Vikor Method

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**Abstract.** The bottled water industry applies various water treatment technologies, with some companies selecting methods that may be less suitable given the type of raw water to be processed. Effective water treatment is crucial to the success of the bottled water industry, as product quality and business processes are highly dependent on the chosen technology. This study aims to evaluate and select the optimal water treatment technology for the bottled water industry using the *Vise Kriterijumska Optimizacija Kompromisno Resenje* (VIKOR) method, alongside an economic evaluation through metrics such as IRR, NPV, and PBP. This method incorporates several relevant criteria, including product quality, efficiency, costs, environmental impact, and customer satisfaction. The research process begins with data collection on various water treatment technologies employed in the bottled water industry within the Pandaan District, Pasuruan Regency, East Java Province. The VIKOR method is then applied to analyze and compare these technologies, while economic evaluation is conducted using metrics such as IRR, NPV, and PBP. The results indicate that the technology used by Company F ranked highest, demonstrating the lowest compromise value (Q). The findings of this study are expected to provide valuable insights for the bottled water industry in selecting the most appropriate water treatment technology and to contribute to research in the field of water treatment. Recommendations for the implementation of the selected technology are also provided to enhance efficiency and product quality.

**Keywords:** Mineral Water Industry; Water Treatment; Drinking Water; VIKOR; Economic Analysis

## INTRODUCTION

Water is a vital resource that supports human life and cannot be replaced. All living things need water for their lives, especially as drinking water. According to the Indonesian Minister of Health Regulation Number 2 of 2023, drinking water is water that is treated or without treatment that meets health requirements and can be drunk directly. In connection with the mandate and targets mandated to the Indonesian government for the Sustainable Development Goals (SDGs) goal 6.1, which is to achieve 100% access to safe drinking water, it is necessary to ensure its fulfillment and it is necessary to supervise the quality of drinking water (Al-Fadhat & Savitri, 2023; K. K. R. Indonesia, 2017; S. Indonesia, 2015; McCowan, 2019; Wuaten, 2023).

Water as drinking water is made by processing raw water. Raw water sources that can be used can consist of springs, surface water (rivers, lakes, reservoirs), groundwater (dug wells, drilled wells), and rainwater. In terms of water quality, the quality of spring water is relatively clear compared to the quality of water sources from surface water in general, thus spring water is better used than surface water. However, the existence of this spring at this time continues to decrease its existence (Hägglund et al., 2018; Han et al., 2024; Ionescu & Diaconita, 2023; Sudradjat et al., 2022; Sururi et al., 2021).

Bottled drinking water (*air minum dalam kemasan*, AMDK) is very popular in the community, especially in urban areas. This type of water is packaged in bottles, gallons, glasses, or sachets in various sizes and prices (Alicea-Planas et al., 2020; Miller et al., 2020; Qian, 2018; Vasiutkina & Lazebnyk, 2020). The Central Statistics Agency (BPS) estimates that 40% of Indonesia's population will use bottled water in 2020. The use of drinking water obtained from refill depots is three times greater than that of branded bottled water. Recent research shows that the trend of using bottled water increases 1.24 times (124%) every year and it is predicted that 50% of the Indonesian population will use bottled water, either refillable or branded.

Indonesia is a country with a population of more than 270 million people. With rapid population growth, the demand for clean and healthy water, especially drinking water, also continues to increase. This certainly provides great bottled water business opportunities for business actors. In addition to having a large market share, the bottled water industry in Indonesia has experienced significant development in recent years. According to data from the Indonesian Bottled Water Industry Association (ASPADIN), bottled water consumption in Indonesia has increased by 10% every year.

Bottled drinking water is classified into 2 types, namely refillable water obtained from refillable drinking water depots (*depot air minum isi ulang*, DAMIU) and branded bottled water (AMDK) such as Aqua, Vit, Le Minerale and similar brands, which are produced by large-scale industries (Daniel, 2022). The results of Hasanah and Suryadinata's research on DAMIU show that the overall quality category of DAMIU's sanitation condition has met the requirements. However, there are conditions if they are not maintained and paid attention to regularly, their function will decrease and are highly dependent on the respective standards issued by DAMIU equipment manufacturers. There is a time limit for both equipment replacement and maintenance. So that the quality of DAMIU is considered to be less hygienic and the quality cannot be consistent in meeting drinking water requirements. Meanwhile, bottled water is preferred and meets the requirements as drinking water. This is supported by stricter regulations and requirements for the bottled water industry regulated by the government (2023).

Bottled drinking water has various types. In *Permenperin RI* number 78 of 2016, there is a change in the scope of bottled drinking water or branded bottled water to Mineral Water, Demineralized Water, Natural Mineral Water, and Dew Drinking Water, each of which has an Indonesian National Standard (SNI) for each product. The definition of mineral water is bottled drinking water that contains a certain amount of minerals without adding minerals with or the addition of oxygen ($O_2$) or carbon dioxide ($CO_2$).

Principal Expert Researcher from BRIN's Center for Environmental Research and Clean Technology, Said (2023) explained that the important thing that must be seen in mineral water is what the technology is, and where the raw water comes from. This means that the technology must be in accordance with the raw water to be used, considering the current diverse and degrading raw water sources. Most of the mineral water industry in Pasuruan Regency uses spring water (artesian) and surface water as its raw water source. This affects the water treatment technology applied, considering that there are standards and requirements that must be met for the mineral water industry, especially the quality of the product content.

There are several technologies found in the field that are used in the treatment of raw water into mineral water. This process is referred to as the water treatment process. In this process, there is a filtration process with various kinds of filters to eliminate contamination and unnecessary substances that are in the raw water. These filters can come from silica filters, carbon filters, zeolite filters, anion-cation resin filters, microfilters, and there are also *reverse osmosis* filters. In addition, there is an infection process as an effort to eliminate microbial contamination such as the addition of ozone, UV lamps, chlorination, and so on so that the water is suitable for drinking and meets the requirements. Each of these filters has specific functions. However, it was found that the water treatment technology was not appropriate, especially when viewed from the raw water used. The sequence modeling of these filters also affects the output of the product, including the utilization of the filter itself if the circuit is not right. However, the orientation of the mineral water industry is a business that is also determined by these 2 things.... The current development of the mineral water business has encouraged drinking water companies to continue to supply water suitable for consumption with the best quality assurance in terms of quality, hygiene, and product safety. Mineral water companies are competing to launch strategies to build unique branding to attract loyal consumers. This is because this business can be said to be a business that is classified as a 'red ocean' with so many business actors competing in the same type of commodity (Indah, 2024). So, departing from the selection of the right water treatment model will lead the mineral water industry to be able to optimally run its business processes.

In East Java Province, especially in Pandaan District, Pasuruan Regency, there are many mineral water industries. This area has the potential for natural resources as a producer of high-quality raw water sources. As an area where there are many factories, Pandaan still has business potential that can be developed, because geographically Pandaan is located close to the foot of Mount Arjuna where the source of spring water can be processed as mineral water products such as Aqua, Flow, Frozen, Amidis, Amsil (Aliefian, 2023).

The mineral water factory in Pandaan has different water treatment technologies. This condition produces the output of different mineral water products. It has not been found how the most ideal and optimal mineral water treatment model is in accordance with the raw water used, namely those derived from artesian water sources. Some technologies are considered inappropriate for the raw water treatment used and not some filters are not theoretically necessary. There have been several studies on water treatment, but only limited to wastewater and clean water. Therefore, a more in-depth study is needed on water treatment in the bottled mineral water industry.

From the potential of the Pandaan District area with its quality raw water sources and as a rapidly developing industrial area, as well as the need for mineral water companies to determine strategies in producing the best and competitive products with the most efficient technology, it is necessary to conduct research on water treatment technology recommendations that can meet these requirements.

Existing research lacks an integrated techno-economic evaluation model to determine the optimal water treatment technology that aligns with both the quality of artesian raw water and operational efficiency in the AMDK industry. Studies often limit themselves to technical performance or economic feasibility alone, without combining both dimensions holistically or using structured decision-making approaches like VIKOR. This study introduces a novel integration of the VIKOR method—a multi-criteria decision-making (MCDM) tool—with economic performance indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PBP) to determine the most optimal water treatment technology. The uniqueness lies in its focus on real-world application in Pandaan District, East Java—an area with high industrial activity and access to artesian water sources. The study also adds value by testing solution stability through sensitivity analysis and offering actionable recommendations for industry players.

The purpose of this study is to identify the main criteria in the selection of water treatment technologies, determine how to measure and compare alternative technologies, and evaluate the performance of various water treatment technologies. In addition, this study aims to apply the VIKOR method in selecting the optimal technology, identifying obstacles in implementation, and providing practical recommendations to improve the efficiency of the production process and the quality of mineral water products.

The benefits of this research are to help mineral water industry players to meet expected quality standards, choose effective and efficient water treatment technologies, and provide better access to safe and quality mineral water to the public. This research also aims to contribute to the development of science and technology, especially in the field of mineral water treatment.

The limitations of the problem in this study include focusing on the latest technologies that can be applied in the mineral water treatment industry in Pandaan District, Pasuruan Regency, as well as the collection of primary and secondary data from reliable sources. This research also does not discuss the political aspects related to the mineral water industry, but rather focuses on technical and economic aspects.

## METHOD

This research utilizes both qualitative and quantitative data obtained from multiple sources, including data on the mineral water industry in Pandaan District, Pasuruan Regency, laboratory test results, and interviews with industry stakeholders. The *Vise Kriterijumska Optimizacija Kompromisno Resenje* (VIKOR) method was employed to determine the most efficient water treatment model, complemented by economic analysis metrics such as *Net Present Value* (NPV), *Internal Rate of Return* (IRR), and *Payback Period* (PBP) to evaluate financial feasibility. Data collection involved semi-structured interviews with mineral water industry representatives and comprehensive literature review. Qualitative data underwent thematic analysis to identify key themes in mineral water treatment, while quantitative data were assessed using a 5-point *Likert scale* to measure water quality and technological performance. During data analysis, the VIKOR method was applied to identify the optimal processing alternative through criterion weighting and calculation of key values using appropriate formulas. This research process further incorporated economic analysis of selected alternatives to outline potential investment benefits and risks in mineral water treatment technology.

## RESULTS AND DISCUSSION

The results of the research that have been obtained are field data processing, interviews with *stakeholders*, and analysis of alternative technology selection through the VIKOR method and economic analysis. The results of each of these methods are used to provide recommendations on the selection of optimal water treatment technology for mineral water industry players to improve the efficiency of the production process and produce quality outputs.

The data collection process was carried out by analyzing mineral water industry data in Pandaan District, Pasuruan Regency, East Java Province, case studies and research related to mineral water treatment technology, government policies and regulations, historical data from various media, and semi-structured interviews with stakeholders including representatives of the mineral water industry. The data processing is then focused on the preparation of alternative selection of mineral water treatment technology that yields optimal results.

The discussion in this chapter begins with the presentation of the results of data collection on mineral water treatment technology applied to the mineral water industry in the Pandaan District, Pasuruan Regency, East Java Province; data on laboratory test results regarding the water quality of mineral water products produced and data from interviews with *stakeholders*. Followed by a comparative analysis using the VIKOR method and the economic feasibility of alternatives through the calculation of NPV, IRR and PBP. These results are then discussed to provide a better understanding of the constraints and challenges in the implementation of water treatment technology in the mineral water industry.

***Data Collection Results***

Data collection activities were carried out on mineral water treatment technology data applied to the mineral water industry in Pandaan District, Pasuruan Regency, East Java Province. From data obtained from the Ministry of Industry's SIINas (National Industrial Information System) in 2024, there are 9 mineral water companies that have established their factories in the Pandaan area. And from data from the Surabaya Industrial Services Standardization and Services Center (BSPJI) of the Ministry of Industry of the Republic of Indonesia, there are 6 factories that take raw water sources from deep water sources (*artesis),* the rest take raw water from PDAM water because the factories do not have drilling facilities. The following is the alternative labeling of companies with raw water from deep water sources as followed in this study:

**Table 1. Labeling of Mineral Water Company in Pandaan with Raw Water Deep Water**

Source : By Researcher

| No. | Company | Alternative Label |
|---|---|---|
| **1** | Company A | PA |
| **2** | Company B | PB |
| **3** | Company C | PC |
| **4** | Company D | PD |
| **5** | Company E | PE |
| **6** | Company F | PF |

The data of the 6 companies will later be recorded as alternatives representing each of the different water treatment technologies. The series of mineral water treatment technologies from each company is in accordance with Appendix 2.

In these different water treatment technologies, a comparison is made on the output results of the technology, namely product water quality data. The data was obtained from the results of tests by the test laboratory of the Surabaya Industrial Services and Standardization Center (BSPJI) which has been accredited by the National Accreditation Committee (KAN). Product water test results data as shown in attachment 3.

According to the mandatory SNI of mineral water number SNI 3553:2016, there are 30 parameters that must be tested and meet the standards. In this study, the quality of mineral water output was focused on 13 main parameters, namely taste, smell, color, pH, turbidity, TDS, iron organic substances, manganese, initial ALT microbial contamination at temperature

22, initial ALT at 36, Coliform and Pseudomonas. This is because these thirteen parameters are considered the most critical parameters that determine the quality of mineral water.

The data of water test results of the water treatment unit's output products showed varied results. The results of organoleptic tests of smell, taste and color tend to produce the same data on each technology, this is related to the use of raw water in deep water which has odor-free, taste and color properties. The same thing in the pH test results, it can be seen that almost all technologies produce output water with a neutral pH of 7 and close to 7. The turbidity or turbidity parameter also shows results that do not differ much between the six technologies.

Another parameter is TDS (*Total Dissolved Water)* which indicates the hardness properties of the water. Water hardness can be removed with filters or processes that can reduce calcium ($Ca^{2+}$) and magnesium ($Mg^{2+}$) ions that are the main causes of hardness. Filters that can remove hardness include ion exchange filters (*softeners*) and R filters (*Reverse Osmosis*) which are currently widely used in water treatment technology. Of the six technologies used, PA, PC, PD and PE are in the range of 200, PB is in the very small value of 2, and PD is in the range of 100. The TDS value also affects the taste produced by mineral water.

In the parameters of organic substances, the results showed that all six technologies produced values below 1. Meanwhile, in iron and manganese metal pollution, the technology also produces mineral water that is still in accordance with standards.

Another critical parameter on mineral water quality is microbial contamination. There are 3 technologies that produce positive values at the initial ALT temperature of 22, namely PC, PD, and PE; and 2 technologies produced positive values at the initial ALT temperature of 36, namely PC and PD. The six technologies did not show positive results in *coliform* contamination, but 3 positive technologies in *Pseudomonas contamination*, namely PC, PD, and PE. Positive microbial contamination results can be caused by several factors, ranging from raw water that does not meet the requirements of raw water quality, filters that are not regularly replaced or cleaned, non-optimal disinfection, and pollution by the environment or operator at the time of filling.

The data from the test results can be summarized in the following table:

**Table 2. Product Water Quality Test Results Data**

Source : By Researcher

| No. | Technology | Test Results | | Result |
|---|---|---|---|---|
| | | Meet | No | |
| 1 | PA | 13 | 0 | 1 |
| 2 | PB | 13 | 0 | 1 |
| 3 | PC | 12 | 1 | 0,92 |
| 4 | PD | 12 | 1 | 0,92 |
| 5 | OR | 12 | 1 | 0,92 |
| 6 | PF | 13 | 0 | 1 |

The water quality data of the output products will later be used as one of the attributes in consideration in the selection of water treatment technology.

***Interview Results***

There are two purposes of the interview activity, the first is an interview to obtain weight data on the criteria carried out on the factory manager or at the same level. The second interview was to obtain investment data on the purchase and installation of mineral water treatment plants carried out in the procurement section, data on ease of maintenance and maintenance carried out by the engineering section, and *loosess data* on the use of raw water carried out in the production section. Interviews were conducted in a structured manner using the questionnaire method. Follow-up interviews were conducted with plant managers or equivalent levels to obtain economic data such as initial investment, operational costs and sales costs, on plants that applied the technology with the highest ratings in the VIKOR test results.

The result of the first interview activity that has been carried out is to obtain weighted data from each criterion based on the level of importance of the criteria. Interviews were conducted with 6 respondents who were factory managers or those at the same level who understood directly the key factors in the production process, representing 6 mineral water industries with different water treatment technologies. Plant managers or equivalents have strategic authority and responsibility for the company and understand the performance of the water treatment system as a whole. Plant managers can also guarantee the validity of data that practically represents the perspective of the end users of the technology. The respondent's profile is as shown in attachment 4.

The data obtained from the interview results was recorded as follows:

**Table 3. Weighting on Criteria**

Source : By Researcher

| No. | Technology | Weighting Criteria | | | | |
|---|---|---|---|---|---|---|
| | | **Output Quality** | **Investment Cost** | **Usage Efficiency** | **Environmental Impact** | **Customer Satisfaction** |
| **1** | PA | 5 | 4 | 4 | 4 | 5 |
| **2** | PB | 5 | 5 | 5 | 5 | 5 |
| **3** | PC | 4 | 4 | 4 | 4 | 5 |
| **4** | PD | 5 | 5 | 5 | 5 | 5 |
| **5** | OR | 4 | 4 | 3 | 3 | 5 |
| **6** | PF | 5 | 5 | 5 | 5 | 4 |
| **Average** | | 5 | 5 | 4 | 4 | 5 |

The use of criterion weights in the VIKOR method is a core component that serves to state the level of relative importance between the criteria considered. In addition, weighting also serves to avoid unrealistic equal treatment of criteria that have different impacts. Weighting also reflects real preferences and priorities for *stakeholders* with a structured and systematic subjective approach.

Processing of criterion weight data using weight aggregation with average calculation. The data shows that the five criteria are important and very important. Criteria for output quality, investment cost and customer satisfaction are considered very important criteria (score 5), while criteria of efficiency of use and environmental impact are considered important criteria (score 4).

This data will be used as the basis for weighting each assessment criteria in the selection of mineral water treatment technology. The results of the second interviews conducted with each of the relevant sections produced the following data:

**Table 4. Interview Results Data**

Source : By Researcher

| No. | Alternatif | Investment Cost | Usage Efficiency | Environmental Impact |
|---|---|---|---|---|
| 1 | PA | 2.000.000.000 | Rare/ 2 | 50 |
| 2 | PB | 4.000.000.000 | Reasonable/ 3 | 30 |
| 3 | PC | 3.800.000.000 | Often/ 4 | 50 |
| 4 | PD | 3.000.000.000 | Reasonable/ 3 | 20 |
| 5 | OR | 2.800.000.000 | Reasonable/ 3 | 30 |
| 6 | PF | 4.000.000.000 | Reasonable/ 3 | 30 |

From the table, it can be seen that the largest investment costs are incurred by PB and PF technologies and the lowest by PE technology. Meanwhile, the reliability of technology is judged from the frequent replacement and repairs that occur rather often by PC technology and rarely by PA technology. For the environmental impact criteria assessed from the raw water discharged compared to the water used, the highest is 50% in PA and PC technology, and at least 20% in PD technology.

The data will represent the value of each criterion in the selection of mineral water treatment technology.

***Data Processing Results***

In this evaluation, an alternative approach and selection were used on mineral water treatment technology using the VIKOR method. The results of each of the VIKOR steps are as follows:

1. Identify criteria and alternatives

   As a preliminary design of the study, the selection criteria were determined as follows:

**Table 5. Criteria for the selection of water treatment technology**

Source : By Researcher

| No. | Criterion | Criteria Code | Weighting Criteria |
|---|---|---|---|
| 1. | Output quality | K1 | 5 |
| 2. | Investment costs | K2 | 5 |
| 3. | Usage efficiency | K3 | 4 |
| 4. | Environmental impact | K4 | 4 |
| 5. | Customer satisfaction | K5 | 5 |

There are 5 criteria that are considered in the selection of water treatment technology. Where these 5 criteria are important things that have a big influence on the business process of the mineral water industry.

The first criterion is output quality, where in the mineral water industry the fulfillment of quality requirements is the main thing. An industry basically aims at profit, so the initial investment cost in procurement and installation is one of the criteria used as a benchmark. Another criterion is efficiency of use, where frequent *replacement of parts* and ease of maintenance will be considerations in the operation of mineral water treatment technology. Furthermore, the criteria regarding environmental impact. The inefficient use of raw water as shown by the large amount of *rejected* and discharged water is one of the important points in the selection of mineral water treatment technology. The last criterion is customer satisfaction, which is indicated by the TDS content value in the output water which indicates at the level of taste preferred by the customer.

The weight of the criteria is obtained from the interview process with plant managers or positions at the level who are considered to have the best understanding of daily operations in depth, have practical experience, and who are responsible for the quality of output from mineral water production.

Meanwhile, the alternatives to be chosen are as follows:

Table 6. Alternative water treatment technology to be selected
Source : By Researcher

| No. | Alternatif | Alternate Codes |
|---|---|---|
| 1. | Water Treatment Technology in Company A | PA |
| 2. | Water Treatment Technology in Company B | PB |
| 3. | Water Treatment Technology in Company C | PC |
| 4. | Water Treatment Technology in Company D | PD |
| 5. | Water Treatment Technology in Company E | OR |
| 6. | Water Treatment Technology in Company F | PF |

The alternative is that each mineral water treatment technology applied differently to the mineral water industry in Pandaan with the same raw water, namely deep water sources/ *artesis*.

2. Compiling criteria and alternatives in the form of a matrix

The next step is to compile the criteria and alternatives to the previous step in a matrix, so that the matrix is obtained as follows:

**Table 7. Criteria and alternatives matrix**
Source : By Researcher

| Aternative | Criterion | | | | |
|---|---|---|---|---|---|
| | K1 | K2 | K3 | K4 | K5 |
| PA | 1 | 2.000.000.000 | 2 | 50 | 203 |
| PB | 1 | 4.000.000.000 | 3 | 30 | 2 |
| PC | 0,92 | 3.800.000.000 | 4 | 50 | 186 |
| PD | 0,92 | 3.000.000.000 | 3 | 20 | 112 |
| OR | 0,92 | 2.800.000.000 | 3 | 30 | 213 |
| PF | 1 | 4.000.000.000 | 3 | 30 | 186 |

3. Normalization of the N data matrix

Based on the data in the matrix in the previous section, normalization is carried out into the following matrices:

**Table 8. Criteria and alternative normalization matrix**
Source : By Researcher

| Aternative | Criterion | | | | |
|---|---|---|---|---|---|
| | K1 | K2 | K3 | K4 | K5 |

| | | | | | |
|---|---|---|---|---|---|
| **PA** | 0 | 1 | 1 | 0 | 0,047393 |
| **PB** | 0 | 0 | 0,5 | 0,666667 | 1 |
| **PC** | 1 | 0,1 | 0 | 0 | 0,127962 |
| **PD** | 1 | 0,5 | 0,5 | 1 | 0,478673 |
| **OR** | 1 | 0,6 | 0,5 | 0,666667 | 0 |
| **PF** | 0 | 0 | 0,5 | 0,666667 | 0,127962 |

At this stage, positive and negative values are produced as the ideal solution of each criterion.

4. Determining the weighted normalization matrix

   At this stage, it is carried out by multiplying the value of the previous stage of normalization data with the value of the weighting criterion. The results of this stage are as follows:

**Table 9. Standardization matrix of weighted criteria and alternatives**

Source : By Researcher

| **Aternative** | **Criterion** | | | | |
|---|---|---|---|---|---|
| | **K1** | **K2** | **K3** | **K4** | **K5** |
| **PA** | 0 | 0,2173913 | 0,173913 | 0 | 0,010303 |
| **PB** | 0 | 0 | 0,086957 | 0,115942 | 0,217391 |
| **PC** | 0,217391 | 0,02173913 | 0 | 0 | 0,027818 |
| **PD** | 0,217391 | 0,10869565 | 0,086957 | 0,173913 | 0,104059 |
| **OR** | 0,217391 | 0,13043478 | 0,086957 | 0,115942 | 0 |
| **PF** | 0 | 0 | 0,086957 | 0,115942 | 0,027818 |

5. Calculating *the value of the Utility measure* (S) and *Regret Measure* (R)

   This stage calculates the values of S and R, with the results as shown in the following table.

**Table 10. S and R values**

Source : By Researcher

| | S | R |
|---|---|---|
| **PA** | 0,401607 | 0,2173913 |
| **PB** | 0,42029 | 0,2173913 |
| **PC** | 0,266948 | 0,2173913 |
| **PD** | 0,691016 | 0,2173913 |
| **OR** | 0,550725 | 0,2173913 |
| **PF** | 0,230716 | 0,11594203 |
| **Min** | 0,230716 | 0,11594203 |
| **Max** | 0,691016 | 0,2173913 |

The value of S in the calculation results above is the calculation of the distance between the coordinates of a pair of objects in the space of distance by applying the concept of absolute difference. This means measuring the distance or proximity of alternative solutions to the ideal and worst solutions in a multidimensional space with several criteria. The smallest result of the S value is 0.23 and the largest is 0.69.

While the value of R is the calculation of distance based on the absolute value of the difference of a pair of coordinate points. If two vectors have different values for each element, the measured distance is the absolute value of the element in that vector, and the amount of data must be the same. The R-value provides a more sensitive measure of distance to the most significant differences between the criteria, as it relies only on the largest differences between the criteria values on the alternatives being compared. It helps in highlighting the biggest difference between the alternative and the ideal solution or the worst solution. The result of calculating the smallest R-value is 0.12 and the largest is 0.22.

6. Calculating the VIKOR index

The final stage of calculation is the calculation on the VIKOR index or the Q value.

In calculating the VIKOR index, it is necessary to consider the influencing preference parameter v. The value of v indicates the level of attention paid to the ideal solution or the worst solution. If the v is larger, more attention is paid to the proximity to the best solution. If the v is smaller, more attention is paid to the proximity to the worst solution. In this study, a v value of 0.5 was used, which means that attention to the best solution and the worst solution is a draw.

The results of the calculation of the VIKOR index in this study are as follows:

**Table 11. VIKOR Index Value**

Source : By Researcher

| No | Alternatif | Q |
|---|---|---|
| **1** | PA | 0,68563 |
| **2** | PB | 0,705924 |
| **3** | PC | 0,539357 |
| **4** | PD | 1 |
| **5** | OR | 0,847609 |
| **6** | PF | 0 |

A smaller Q value indicates that the alternative is closer to the best (ideal) solution, while a larger Q value indicates that the alternative is worse or farther from the ideal solution and closer to the worst solution. From the data above, the smallest index value in the PF alternative and the largest index value in the PD alternative.

7. Determining alternative ratings

From the value of the index that has been obtained in the previous step, the ranking is carried out from the smallest value to the largest value as follows:

**Table 12. VIKOR Index Ranking Results**

Source : By Researcher

| No | Alternatif | Q |
|---|---|---|
| **1** | PF | 0 |
| **2** | PC | 0,539357 |
| **3** | PA | 0,68563 |
| **4** | PB | 0,705924 |
| **5** | OR | 0,847609 |
| **6** | PD | 1 |

In the ranking step, the results were obtained that the number 1 ranking was PF technology with the smallest VIKOR (Q) index value of 0. This means that the most optimal alternative technology when viewed from considering 5 criteria is PF technology.

8. Propose a compromise solution

This stage is carried out by conducting a fulfillment test of 2 conditions, namely condition 1: acceptable advantage and condition 2: *acceptable stability in decision making* in technology with the first ranking result, namely PF technology.

The first test is the *Acceptable Advantage test,* which has the condition that the best alternative must have a considerable difference from the second-ranked alternative. So that the calculation:

Q (A1) : 0
Q(A2) : 0,54
m (alternate amount) : 6

$$DQ = \frac{1}{(m-1)}$$

$$DQ = \frac{1}{(6-1)} = 0,2$$

$$Q_{(A2)} - Q_{(A1)} = 0,54 - 0 = 0,54$$

0.54 > 0.2 means that condition 1 is met, and the A1 alternative or PF technology is the single compromise solution.

Meanwhile, the fulfillment test of condition 2 is stability in decision-making. The best solution chosen must remain stable when v = 0.5 or v > 0.5. The test results show that when the value of v is raised to 0.7, the best solution is still the PF alternative. Here are the results:

**Table 13. VIKOR Index Result with v = 0.7**

Source : By Researcher

| Peringkat | Technology | Q (VIKOR index) |
|---|---|---|
| **1** | PF | 0 |
| **2** | PC | 0,3551 |
| **3** | PA | 0,559882 |
| **4** | PB | 0,588294 |
| **5** | OR | 0,786652 |
| **6** | PD | 1 |

The stable PF technology in the first rank indicates that the results of the VIKOR test are stable, so it can be concluded that the most ideal water treatment technology is PF technology.

9. Sensitivity test on VIKOR results

Sensitivity testing is an important step to evaluate the robustness of decision-making results, especially in multicriteria methods such as VIKOR which are heavily influenced by criterion weight. If the results change drastically when the weight of the criteria is changed, then the technology recommendations are less stable and should be reconsidered.

In this study, drastic changes were made to the weight of the criteria at random as follows:

**Table 14. Weighting criteria**

Source : By Researcher

| | K1 | K2 | K3 | K4 | K5 |
|---|---|---|---|---|---|
| **Initial Weight** | 5 | 5 | 4 | 4 | 5 |
| **Weight scenario A** | 4 | 5 | 3 | 5 | 4 |
| **Weight scenario B** | 4 | 3 | 4 | 4 | 5 |
| **Scenario C weight** | 5 | 3 | 4 | 5 | 5 |

The calculation of VIKOR with the sensitivity test weight in detail is written in appendix 5. The results of the technology ranking are recorded in the following table:

**Table 15. Technology Rating Results with Sensitivity Test**

Source : By Researcher

| Peringkat | Initial Results | | Scenario A | | Scenario B | | Scenario C | |
|---|---|---|---|---|---|---|---|---|
| **1** | PF | 0 | PF | 0,01 | PF | 0,02 | PF | 0,00 |
| **2** | PC | 0,53 | PC | 0,2 | PC | 0,29 | PA | 0,27 |
| **3** | PA | 0,68 | PB | 0,39 | PA | 0,41 | PC | 0,50 |
| **4** | PB | 0,70 | OR | 0,54 | OR | 0,59 | PB | 0,72 |
| **5** | OR | 0,84 | PA | 0,66 | PB | 0,76 | OR | 0,81 |
| **6** | PD | 1 | PD | 1 | PD | 0,79 | PD | 1,00 |

The results showed that the F technology remained in first place in all scenarios, indicating that the compromise solution generated by the VIKOR method was *robust* to changes in criterion weights.

10. Economic Analysis

Economic analysis was conducted to determine the potential financial benefits and risks associated with investing in water treatment technology in companies F. NPV (Net Present Value) calculation was carried out to assess whether the chosen technology provides positive added value after taking into account the cash flow generated over the life of the project, minus the initial investment. The initial investment in company F includes the cost of purchasing land and buildings, WT units, filling machines, laboratories, test equipment, office inventory, vehicles, as well as legality and certification, with a total initial investment cost of IDR 19,290,000,000. The company's operating costs include labor costs for 38 employees, bottle, gallon, and carton packaging materials, as well as consumption and electricity costs, which total Rp 5,985,541,840 per year. The company's revenue comes from the sale of bottles and gallons, with a total annual revenue of IDR 33,005,280,000. Based on the calculation of net cash flow of IDR 27,019,738,160 and the assumption of a project life of 20 years with an interest rate of 15%, NPV is calculated to evaluate the financial feasibility of this investment.

**Table 14. NPV calculation table**

Source : By Researcher

| Year | Net Cash Flow (Rp. Billion) | 15% Off | Discounted Cash Flow |
|---|---|---|---|
| 1 | 27,02 | 0,87 | 23,50 |
| 2 | 27,02 | 0,76 | 20,43 |
| 3 | 27,02 | 0,66 | 17,77 |
| 4 | 27,02 | 0,57 | 15,45 |
| 5 | 27,02 | 0,50 | 13,43 |
| 6 | 27,02 | 0,43 | 11,68 |
| 7 | 27,02 | 0,38 | 10,16 |
| 8 | 27,02 | 0,33 | 8,83 |
| 9 | 27,02 | 0,28 | 7,68 |
| 10 | 27,02 | 0,25 | 6,68 |
| 11 | 27,02 | 0,21 | 5,81 |
| 12 | 27,02 | 0,19 | 5,05 |
| 13 | 27,02 | 0,16 | 4,39 |
| 14 | 27,02 | 0,14 | 3,82 |
| 15 | 27,02 | 0,12 | 3,32 |
| 16 | 27,02 | 0,11 | 2,89 |
| 17 | 27,02 | 0,09 | 2,51 |
| 18 | 27,02 | 0,08 | 2,18 |
| 19 | 27,02 | 0,07 | 1,90 |
| 20 | 27,02 | 0,06 | 1,65 |
| | **Total** | | 169,13 |

NPV = Rp. 169.13 billion – Rp. 19.29 billion
= Rp. 149.84 billion (positive)

11. IRR

The IRR value in economic analysis is used to measure the rate of return on investment of a project that is equivalent to the discount rate at which the NPV becomes zero. An IRR higher than the discounted rate indicates that the project is economically viable. The IRR calculation is carried out using the trial and error method of NPV calculation. From this method, an IRR value of 404 % was obtained which resulted in NPV = 0 shown in the following table:

**Table 17. Trial Results Table Discount rate with NPV=0**

Source : By Researcher

| Year | Discounted Cash Flow |
|---|---|
| 1 | 5,36 |
| 2 | 2,68 |
| 3 | 1,79 |
| 4 | 1,34 |
| 5 | 1,07 |
| 6 | 0,89 |
| 7 | 0,77 |
| 8 | 0,67 |
| 9 | 0,60 |

| | |
|---|---|
| **10** | 0,54 |
| **11** | 0,49 |
| **12** | 0,45 |
| **13** | 0,41 |
| **14** | 0,38 |
| **15** | 0,36 |
| **16** | 0,34 |
| **17** | 0,32 |
| **18** | 0,30 |
| **19** | 0,28 |
| **20** | 0,27 |
| **Total** | 19,29 |

NPV : Cash Flow – Total Discounted Cash Flow
: Rp. 19.29 billion – Rp. 19.29 billion
: 0

The IRR value obtained is far above the interest rate value (404% > 15%), which means that a project with *water treatment* technology in company F is feasible.

12. PBP

The PBP (*Pay Back period)* calculation is used to determine the period of time required for the factory's initial investment to be repaid through the cash flow generated. PBP can be a simple indicator of investment risk, where the faster the return time, the lower the financial risk incurred. The calculation is made by dividing the initial investment by the annual cash flow, according to the following calculation:

PBP : Initial investment : annual cash flow
: Rp. 19,290,000,000 : Rp. 27,019,738,160
: 0,58

This shows that within 0.58 years, companies with *water treatment* technology F can return their initial investment. Time tends to be short, so the project is considered feasible.

13. Comparison with other water treatment technologies

The economic analysis was not only carried out on the water treatment technology with the highest VIKOR score, but also on the other two technological alternatives that were ranked in the top 3. This aims to provide a more comprehensive picture of the financial feasibility of each technology choice. So that decision-making not only considers technical performance, but also investment efficiency and potential profits. The best technology is technically not necessarily the most economically advantageous. This is in accordance with the principle of comprehensive multi-criteria evaluation, so that it can provide an overview for the industry to make adjustments to investment strategies in accordance with financial conditions and operational targets.

Economic analysis is carried out on companies C and A, which are the companies with the second and third ranks. The complete calculation is in accordance with appendix 6. The summary of the calculation results is compared with the results of economic analysis on company F, according to the following table:

**Table 18. Economic Evaluation Results in Company F compared to C and A**

Source : By Researcher

| No | Company | NPV | IRR | PBP | Initial Investment |
|---|---|---|---|---|---|
| **1** | F | 149,84 M | 404 % | 0.58 years | 19.29 M |
| **2** | A | 1,538.79 M | 3007 % | 0.11 years | 29.00 m |
| **3** | C | - 9.16 M | 0 % | 3.01 years | 18.03 M |

Based on the results of the economic analysis, company A has a larger NPV and IRR, and a faster return on capital time compared to company F. However, the initial investment required is much larger than the initial investment for company F. As for company C, a negative NPV value is generated which means the company is not viable. In addition, the value at the IRR value of 0% remains negative, which means that the company is not feasible because the cash flow is too small compared to the investment. Even though the initial investment required is also almost as large as that of company F, even though the time required for the return on the initial investment is 3.02 years. Thus, it can be concluded that from the economic analysis of company F is considered the most viable to operate, on the grounds that the initial investment capital is not too large and the NPV, IRR, and PBP values are very adequate to indicate a company that is viable for operation.

## CONCLUSION

The research findings highlight that the main criteria for selecting water treatment technology in the mineral water industry are output water quality, cost efficiency, effectiveness, environmental impact, and customer satisfaction. Using the VIKOR multicriteria approach enables a balanced and objective comparison of alternative technologies, revealing that Technology F is the most optimal choice, followed by Technologies C, A, B, E, and D. The VIKOR method effectively integrates technical and economic considerations, providing a robust foundation for decision-making. However, industry implementation faces challenges such as limited technical expertise and high costs. The study recommends that mineral water producers adopt Technology F to enhance process efficiency and product quality. For future research, it is suggested to implement Technology F in new mineral water plants, compare criteria weights using average aggregation or alternative methods such as AHP, evaluate other decision-making techniques like VIKOR versus AHP or PROMETHEE, and incorporate sustainability analysis as an additional selection criterion for water treatment technology in the industry.

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