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The Influence of River Filtration Water on the Nutritional Content of Red Spinach Plants (*Amaranthus tricolor* L)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Background: The cultivation of red spinach in urban farming is expected to meet the needs of people in urban areas for vegetable consumption. It is feared that using contaminated river water for irrigation will reduce the nutritional value of spinach plants. The purpose of this study was to determine the effect of water filtration on the nutritional content of Red Spinach plants (*Amaranthus tricolor* L).
Methods: This is an experimental study with a post test control group design.
Results: The results showed that the quality of the filtered water was superior to river water and met the Indonesian Government Regulation Attachment VI of the National Water Quality Standard, making it suitable for crop irrigation. The highest water content found in leaves with water filtration treatment was 86.464%, and the highest protein content in leaves with a value of 0.934% in the filtration water treatment, and the best fat content in leaves with a concentration value of 0.0631% in the filtration water treatment. The Fe, Ca, Vit A, and Vit C content remained relatively constant across the three treatments.
Conclusion: Filtered water treatment yields superior results and is more likely to be used to replace river water.

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1. INTODUCTION

Some farmers are forced to use wastewater for irrigation of food crops due to the unequal distribution of freshwater resources around the world. Irrigation of untreated wastewater can cause various environmental and human health problems [1]. Since 2003, Indonesia has faced an irrigation water shortage, and one strategy for overcoming it is to use domestic wastewater. An assessment of the potential for domestic wastewater in Indonesia in 2020 yields a yield of approximately 228.12 m^3/second. In Java, it is around 132.38 m^3/second, with the potential for nutrients in the form of Nitrogen around 208,740 tons/year or the equivalent of 386,556 tons/year; phosphorus around 41,748 tons per year, which is equivalent to 115,967 tons per year for Triple Super Phosphate (TSP); Potassium: 83,496 tons per year, or equivalent to 185,547 tons per year [2]. Alternative domestic wastewater filtration, which is discharged into river water bodies, can be used to alleviate the crop irrigation water crisis. Although the potential for reusing domestic wastewater can support sustainable agriculture, its application requires the development of management systems and technologies to mitigate the risks of negative health and environmental impacts [3].

According to the global commitments stated in the Sustainable Development Goals, one of the most important issues is food security and sustainable agriculture (SDGs). The process of growing, developing, and distributing various agricultural products in urban areas using human, land, and water resources. Vegetable crops dominate urban farming due to their ease of application [4]. Red spinach is one of the vegetable commodities that has more nutrition than green spinach [5-7]. Red spinach (*Amaranthus tricolor L.*) is a type of vegetable plant that is commonly found in urban areas and has a nutrient-dense nutrient content that is essential for the body [8]. There are calories, carbohydrates, protein, fat, vitamins (A, B1, E, C, and folate), and minerals in 100 grams of red spinach [9].

In addition to the increasing difficulty of finding community-owned agricultural land for urban agriculture, the need for irrigation water must be considered. Rivers, as water bodies receiving domestic waste, have the potential to be used as irrigation water sources, but public acceptance is still low due to the emergence of unpleasant odors and concerns about plant quality. The purpose of this research is to look at how filtered river water affects the nutrient content of red spinach plants.

2. METHODS

Filtration in a clean water treatment system is the process of removing fine particles or flocs that have escaped from the sedimentation unit, where these particles will be retained on the filter media as long as the water passes through the media [10]. Filtration is required to complete the reduction of contaminant levels such as bacteria, color, taste, odor, and iron (Fe) content, resulting in clean water that meets clean water quality standards. The filtering medium is the filtration material and the component of the filter that produces the filtration effect. The filter media is made up of materials that fill or are arranged in the filter, which is located between the inlet and outlet. The basic principle of filtration is the physical, chemical, and biological separation or filtering of particles that are not deposited in the sedimentation process through porous media [11]. The following is the River Water Filtration Design that was used in the study (Fig.1).

2.1 Information

Fig. 1 shows the river water filtration design scheme used in this study. The design consists of two stages: coagulation, flocculation, and sedimentation, followed by filtration, as follows: 1. Potassium alum. 2. Line solution. 3. Gravel. 4. Sedimen tank/flocculation process 5. Sand filter. 6. Waste water 7. Active carbon. 8. Active sand.

This is an experimental study with a posttest control group design. The subjects of this study were red spinach plants treated with river water, treated river water (filtration water), and well water. Major components of spinach plants are bound variables (water content, fat, protein and carbohydrates).

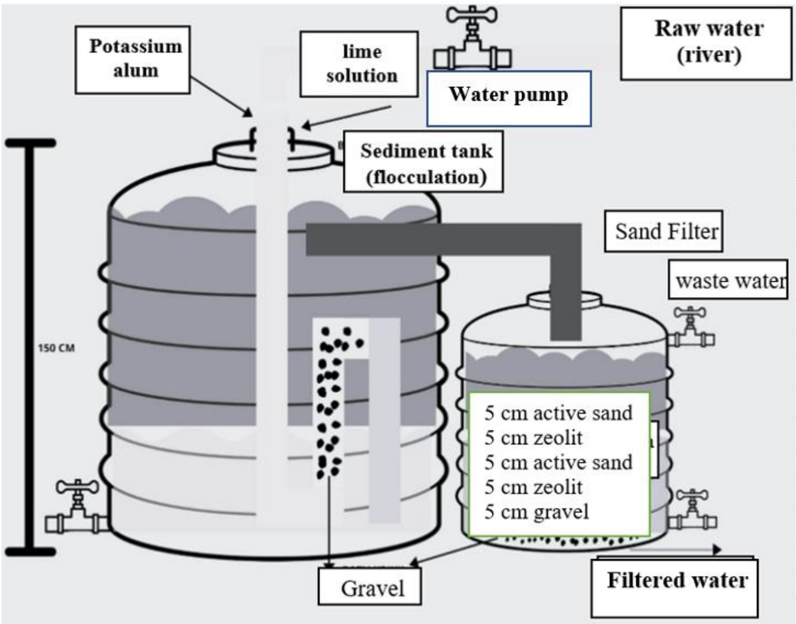

Fig. 1. River water filtration design
Data source: primary data- author's design

Proximate analysis was used to determine the major components of red spinach, which included water, ash, carbohydrate, fat, and protein content. Proximate analysis data is useful in comparing the quality of similar commodities, whether it is potential as a food source of calories, a source of protein, or a source of minerals. The results of the analysis of the proximate content of red spinach between treatments with river water irrigation, filtration water, and well water are presented in tabular form and compared using the Anova test.

3. RESULTS

The results of the irrigation water quality analysis (river water, filtration water, and well water) are as follows: (Table 1).

The following values were obtained from the Proximate Levels Analysis in Red Spinach Plants (*Amaranthus tricolor L*) (Table 2 and Table 3).

4. DISCUSSION

Quality of Irrigation Water, Irrigation water used for agriculture should meet class 4 irrigation water quality standards in accordance with Government Regulation of the Republic of Indonesia Number 22 of 2011 concerning Implementation of Environmental Protection and Management, Appendix VI (National Water Quality Standards), so that the irrigation water is suitable for plant irrigation. According to Table 1, river water is classified as class 4, whereas filtration water and well water are classified as class 2. So, in general, the water used in this study is consistent with its designation as crop irrigation water [12]. The analysis of the quality of irrigation water from filtration yielded positive results, so it is hoped that it will provide higher quality agricultural products than irrigation with river water mixed with domestic waste.

Nutritional Content of Red Spinach **(***Amaranthus tricolor L*), Water content: The amount of water in a plant can affect its shape, texture, and morphological appearance [13]. The ability to predict plant age, plant quality, and plant health can be gained by determining the water content of a plant, including leaves and stems. Because turgor pressure has a strong influence on shelf life, the higher the water content contained, the longer the shelf life [14]. Water balance describes the condition in which the amount of water leaving the plant body (transpiration) equals the amount of water entering (root absorption) [15]. To prevent drought, efforts must be made to regulate irrigation or balance water requirements. Drought-related physiological processes that can be measured include turgor pressure, stomata opening, metabolic rate, enzyme damage, and root density.

Table 1. Results of Irrigation Water Quality Analysis

Parameter	Unit	River water	Filtration Water	Well water	Quality Standard No.22 Year 2021, Annex VI (National Water Quality Standard)			
					Class 1	**Class 2**	**Class 3**	**Class 4**
Temperature	^{o}C	30	30	30	Dev 3	Dev 3	Dev 3	Dev 3
pH		6	7	7	6-9	6-9	6-9	5-9
BOD5	mg/liter	30	2,2	5	2	3	6	12
COD	mg/liter	75	28	11	10	25	40	80
DO	mg/liter	0	3,93	5,26	6	4	3	1

Table 2. Results of analysis of proximate levels in red spinach (*Amaranthus tricolor L*)

Content Type	Water (%)		Ash (%)		Fat (%)		Protein (%)		Carbohydrate (%)	
	Leaf.	**Stem**	**Leaf.**	**Stem**	**Leaf.**	**Stem**	**Leaf.**	**Stem**	**Leaf.**	**Stem**
A, Water Filtration	86,464 ±0,168	91,012 ±0,047	1,074 ±0,031	1,192 ±0,024	0,0631 ±0,002	0,1024 ±0,004	0,934 ±0,006	4,857 ±0,049	1,465 ±0,173	2,836 ±0,095
B, River water	86,061 ±0,168	90,588 ±0,047	1,066 ±0,029	1,186 ±0,024	0,0628 ±0,002	0,1055 ±0,004	0,929 ±0,006	4,834 ±0,049	1,880 ±0,170	3,286 ±0,066
C. Well water	84,623 ±0,165	89,074 ±0,047	1,051 ±0,030	1,167 ±0,024	0,0617 ±0,002	0,1003 ±0,004	0,914 ±0,006	4,754 ±0,048	3,351 ±0,169	4,906 ±0,093

Table 3. Test statistics

Dependent variable	Type of Water Media	Normality test		Variance Test		Anova Test	
		p value	Conclusion	p value	Conclusion	p value	Conclusion
Leaf Moisture Content	Filtration	0,453	Normal	0,999	Same data variance	0,000	There is a significant difference
	River	0,451	Normal				
	Well	0,456	Normal				
Stem Moisture Content	Filtration	0,754	Normal	0,998	Same data variance	0,000	There is a significant difference
	River	0,757	Normal				
	Well	0,762	Normal				
Leaf Ash Content	Filtration	0,385	Normal	0,990	Same data variance	0,862	There is no difference
	River	0,176	Normal				
	Well	0,391	Normal				
Stem Ash Content	Filtration	0,872	Normal	0,997	Same data variance	0,746	There is no difference
	River	0,889	Normal				
	Well	0,894	Normal				
Leaf Fat Content	Filtration	0,414	Normal	0,998	Same data variance	0,863	There is no difference
	River	0,414	Normal				
	Well	0,417	Normal				
Stem Fat Content	Filtration	0,520	Normal	0,882	Same data variance	0,693	There is no difference
	River	0,181	Normal				
	Well	0,513	Normal				
Leaf Protein Content	Filtration	0,972	Normal	0,988	Same data variance	0,087	There is no difference
	River	0,972	Normal				
	Well	0,987	Normal				
Stem Protein Level	Filtration	0,987	Normal	0,999	Same data variance	0,330	There is no difference
	River	0,987	Normal				
	Well	0,986	Normal				
Leaf Carbohydrate Content	Filtration	0,833	Normal	0,999	Same data variance	0,000	There is a significant difference
	River	0,808	Normal				
	Well	0,834	Normal				
Stem Carbohydrate Content	Filtration	0,449	Normal	0,911	Same data variance	0,000	There is a significant difference
	River	0,776	Normal				
	Well	0,445	Normal				

The turgor pressure of plant cells influences physiological activities such as leaf development, stomata opening, photosynthesis, and root growth. The turgor pressure on the leaves and stems, which is heavily influenced by water content, is one indicator of plant health [16]. According to Table 1, the highest water content is found in red spinach leaves treated with filtration water, with a value of 86.464%, and the lowest is 84.623% with well water. It is possible in water treated with filtration because the quality of filtered water is higher than that of river water mixed with sewage. domestic and borehole water This study's findings are nearly identical to those of the red spinach study. The freshness level of red spinach is quite good, with 86.85% of the leaves sold in the Sunter market in North Jakarta indicating that it does not wilt [17] and the water content of red spinach in Inceptisols Land, Pegok Village, Denpasar, which ranges between 83.82% and 87.89% [18]. Meanwhile, Rosdiana Thalib's research discovered a difference of 81.77% in the water content of red spinach in the traditional market and 68.88% in the water content of red spinach in the modern market [19]. The water content in the leaves and stems of red spinach differed significantly between plants watered with filtered water, well water, and river water, according to the Anova test (Table 3).

Ash Content, The results of the ash content analysis of red spinach are shown in Table 2. The ash content obtained from the proximate analysis of spinach leaves with river water irrigation resulted in an average yield of 1.066% with a standard deviation of 0.029, whereas irrigation with filtration water resulted in an average yield of 1.066% with a standard deviation of 0.029. Well water irrigation yields 1.074% with a standard deviation of 0.031, while surface water irrigation yields 1.051% with a standard deviation of 0.031. The treatment with filtration irrigation had the highest ash content. The ash content in the proximate analysis demonstrates the abundance of minerals in red spinach. The ash content of a food sample is the residue left after it is completely burned in an ashing furnace. The ash content describes the amount of minerals that have not been burned into volatile substances [19]. The low ash content is due to the oven's heating process, which does not produce inorganic substances, which are the by products of the combustion of an organic material. Table 3, the ANOVA test results = 0.862 (there is no difference in the ash content that is watered with three different types of water), but the ash content with the irrigation water filtration treatment shows the highest results, indicating the highest mineral content.

Fat content, based on proximate analysis, the fat content in red spinach leaves is 0.0631% (in the treatment of filtered water), 0.0628% (in the treatment of river water), and 0.0617 % (in the treatment of well water). The average proximate concentration of fat content was not significantly different despite the sig value of 0.863, base on anova test [20]. Table 2 shows the highest fat content in the filtered water treatment. Fat can be used to provide energy reserves for the plant's metabolic processes [20]. Adipose tissue is a type of connective tissue made up of lipid-rich cells known as adipocytes. Adipose tissue's function is to store energy in the form of fat. Adopose tissue can be found on leaves and stems, but it is most commonly found beneath the skin or attached to internal organs [21]. According to the Indonesian government, the filtered water contains BOD_5 2.2 mg/liter and COD 28 mg/liter, putting it in the class 2 category (national water quality standards). This makes filtered water a good medium for the growth of red spinach, while increasing the fat content in red spinach's parenchymal adipose tissue.

Protein Concentration Protein is an important nutrient for plants because it functions as a constituent and regulator of enzymatic metabolism in plants. Protein contains amino acids that contain elements C and N. Protein molecules have the ability to bind phosphorus, sulfur, iron, and copper [20]. The results of the analysis of the average protein content in red spinach leaves are shown in Table 2, from the highest to 0.934 % (treatment with filtered water), 0.929 % (treatment with river water) and 0.914 (treatment with well water) [20]. This is because the water quality used in this study is still suitable for class 2 irrigation water, which is superior to river water quality. This suitability improves water metabolism, sunlight intensity for photosynthesis, and other environmental conditions. Photosynthesis generates carbohydrates and protein-building compounds, making them a better medium [20]. Although the ANOVA test yields a p value of 0.087, it indicates that there is no significant difference in the average proximate concentration of red spinach leaf protein content with irrigation treatments: river water, filtration, or well water.

Carbohydrate Content. Table 2 shows the results of the carbohydrate level analysis in red spinach leaves. The highest average value obtained with well water treatment is 13.351%, river water treatment is 11.880%, and filtration water treatment is 11.465%. The This is due to the high carbohydrate content causing high BOD and COD, which causes the metabolism of river waters to increase (class 4 category, classification and water quality criteria: water that can be used to irrigate crops), which is still allowed but is included in the higher category. worse than class 2, which includes filtered water and well water [22]. Anova test yield a value of Sig.= 0.00, indicating that the average proximate concentration of carbohydrates in spinach leaves differs significantly.

5. CONCLUSION

Water quality with filtration treatment (category class 2) is better than river water contaminated with domestic waste (category class 4). The results of the analysis of proximate levels in red spinach (*Amaranthus tricolor* L) revealed higher water, fat, and protein content in the leaves of the red spinach plant (*Amaranthus tricolor* L).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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