

Transforming Silica Water Filter Waste into Sustainable Fertiliser

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DOI: <https://doi.org/10.30880/rpmme.2025.06.02.002>

Article Info

Received: 24 June 2025

Accepted: 27 October 2025

Available online: 10 Disember 2025

Keywords

Coffee powder, fertiliser, growth,
organic, silica waste, soil pH,
spinach, sustainable

Abstract

This study examines the reuse of silica waste from water filters combined with coffee powder as a sustainable fertilizer. Spinach was selected to evaluate the effects of silica ratios at 0%, 10%, 20%, and 30% on plant growth and soil pH. The combination of 20% silica with 30% coffee powder yielded the tallest plants and the highest number of leaves. Soil pH remained neutral, indicating the stability of the amendment. The findings suggest that this low-cost formulation can improve crop performance. This method also promotes sustainable waste management by repurposing industrial and organic residues.

1. Introduction

According to April Schroeder [1], the quantity of water utilised and the source water's quality influence how frequently it needs to be changed. As a rule of thumb, it should be changed every three to six months. After the period, the old water filter becomes unusable and is thrown away. Thus, this project aims to reduce the waste from the water filter and recycle it to become a fertiliser by extracting the silica (SiO_2). This project also aims to encourage sustainable activities for tackling environmental issues and improving long-term well-being for current and future generations.

The objective of the study was to make fertilizer from waste material from silica water filters. and coffee powder. Silica waste was incorporated into the fertiliser at different concentrations (0%, 10%, 20% and 30%) and coffee powder waste (20%, 30%, 40% and 100%). Soil pH and growth characteristics of Spinach plants grown in soil were researched regarding the influence of varying silica concentration.

Malaysia produces a large amount of organic and industrial waste that remains underutilised. For instance, about 16,700 tonnes of food and kitchen waste are generated daily, with over 70% being wet organic material suitable for composting [2]. Coffee grounds from cafes and homes form a major part of this waste, representing 45% of coffee by-products globally [3]. Most of these wastes, along with silica-rich filter media from water treatment, are landfilled and emit methane and other pollutants [3]. The brewing industry alone produces about 378 million kg of spent diatomaceous earth each year, often discarded or recycled into low-grade products [4].

2. Methodology

Methodology highlighted the flow of the research (Fig. 1), procedure, and method on how to achieve the objectives of this research. The research was comparing the three silicas' composition that mixed with fertiliser and studying the impact on the growth of the plant.

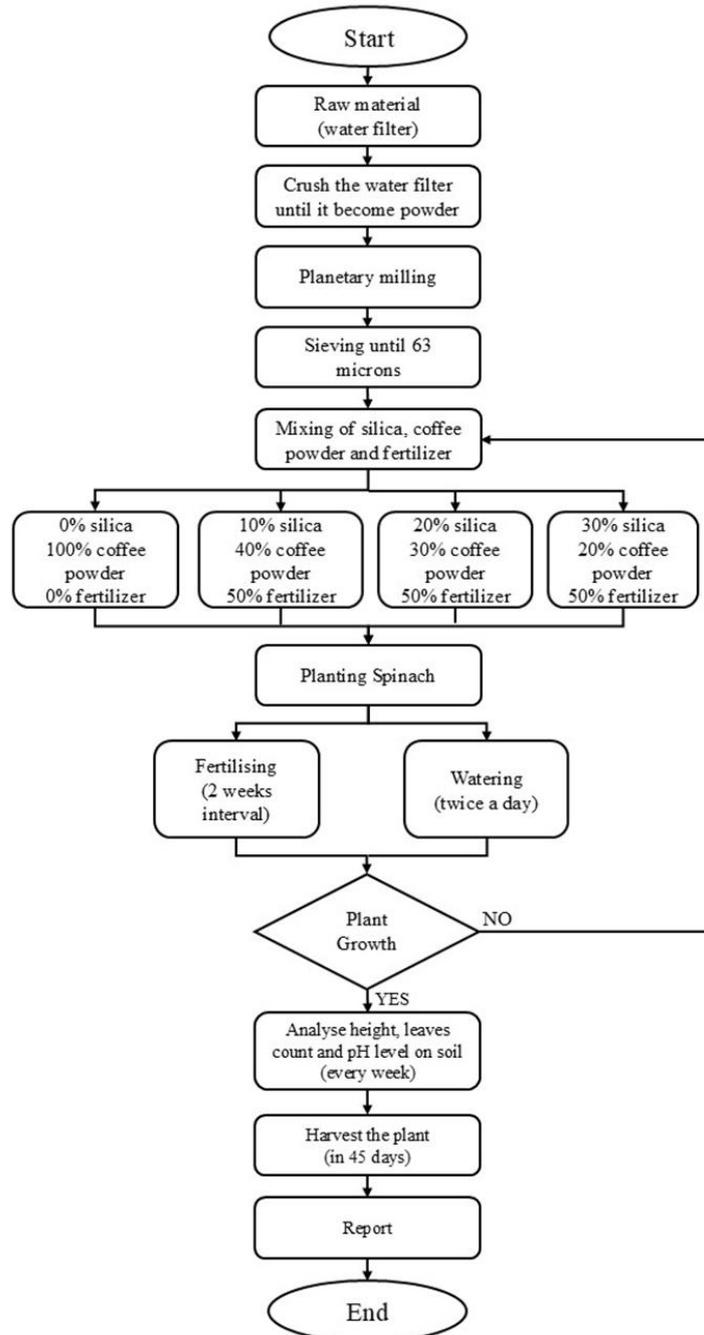


Fig. 1 Flowchart of the research

2.1 Sample Preparation

Firstly, the silica water must be crushed by a hammer first to get into the ball mill machine. To make it finer, the silica water filter was crushed and then put into the ball mill machine in the Polymer Lab at UTHM. The ball mill was spinned with milling balls inside to make the powder finer and smaller. After that, the milled silica powder was then sieved by the sieve shaker, which was also at the same Polymer Lab.

For the sieving process, the powder that was crushed was then sieved until it reached 63 µm (micron, micrometre) or smaller. This technique is crucial for increasing silica bioavailability in soils. Fine silica particles in this size range have a substantially larger surface area-to-volume ratio, allowing for faster breakdown into monosilicic acid (H₄SiO₄), the only form of silicon absorbable by plants [5].

2.2 Sampling

The mixing process is to combine the silica powder that was crushed with the chosen fertiliser. The ratio of silica is 0%, 10%, 20% and 30% and the ratio of the coffee powder is 20%, 30%, 40% and 100%. Table 1 shows the composition of the silica and coffee powder mixed with the fertiliser.

Table 1: *The composition of silica and NPK*

Sample	Composition of Silica	Composition of Coffee Powder	Composition of Fertiliser
1	0%	100%	0%
2	10%	40%	50%
3	20%	30%	50%
4	30%	20%	50%

As mentioned before, there are three different compositions of silica water filter and coffee powder, with a single sample without silica and coffee powder added as a comparison. The sampling approach is five plants for a single setup, a total of 20 samples. Table 2 below shows the naming of each sample according to its parameters.

Table 2: *The specimen's name based on the sample*

Parameter	Sample Name
0% Silica, 100% Coffee Powder	PA1
	PA2
	PA3
	PA4
	PA5
10% Silica, 40% Coffee Powder	PB1
	PB2
	PB3
	PB4
	PB5
20% Silica, 30% Coffee Powder	PC1
	PC2
	PC3
	PC4
	PC5
30% Silica, 20% Coffee Powder	PD1
	PD2
	PD3
	PD4
	PD5

3. Results and Discussion

The planting process starts with growing the seedlings before they are transferred into a bigger pot. Transplanting seedlings to the main growing area starts off the plant's life with the best chance for growth, development, and maturity. The use of growing seedlings indoors or in seed trays also frees space and time as well since planting can be done selectively, and harvesting time is all year round.

Firstly, fill the seedling tray with the medium of the plant, in this case is peat moss. After that, make a hole in each section of the tray about 3 mm to 4 mm to put the seed inside and cover it with the peat moss. Make sure to water the seedlings gently to prevent the seeds from being carried away by the water. To prevent this, it is recommended to use a bottle spray as it can adjust the spread of the water and control the water as seedlings just need a small amount of water. Water the seedlings twice a day. After that, cover the seedling tray with an opaque object such as plastic or polystyrene for a few days.

After a week of planting the seedlings, they can be transferred into bigger pots to let the plants continue to grow. Fill the pots with the plant media (peat moss) and make a hole wide enough to fill the seedlings. Need to make sure that the seedlings were in place and tightly bound to avoid them moving during watering. The specimens were watered twice a day, which was sufficient in the morning and evening. The fertilizer was applied fortnightly with 5 grams of the mixture of fertilizer and silica based on the composition. Fig. 2 shows the specimen planted inside the net.



Fig.2 The specimens after being transferred inside the net

In this study, the parameters were divided into two categories: growth parameters and quality parameters. Plant data were analysed based on observations taken both during the growth phase and after harvesting, with a focus on physical and dimensional characteristics. Growth parameters mainly assessed the rate and height of plant development. Each specimen's height was measured weekly to monitor progressive growth. In addition, the number of leaves was counted, as this visual trait reflects the influence of silica during the plant's development stage. Table 3 shows how the data table should be.

3.1 Height of Plant

Fig. 3 and Table 3 show the graph of the average height of the sample from Week 0 to Week 6 and the data table for the average height of each sample. Based on Fig.3 and Table 3, it shows that sample PC has the highest average height at 9.83cm, followed by PD at 8.94 cm, next to the standings is PA with a small difference at 8.1 cm, and at the last place was PB, which was only at 5.24 cm. Silica enhances cell wall reinforcement, nutrient uptake, and overall plant vigor, allowing plants to maintain stronger structures and achieve higher vertical growth [6]. Additionally, coffee powder contributes essential macronutrients (N, P, K) and improves soil porosity and water retention, which optimizes nutrient availability in the root zone [7].

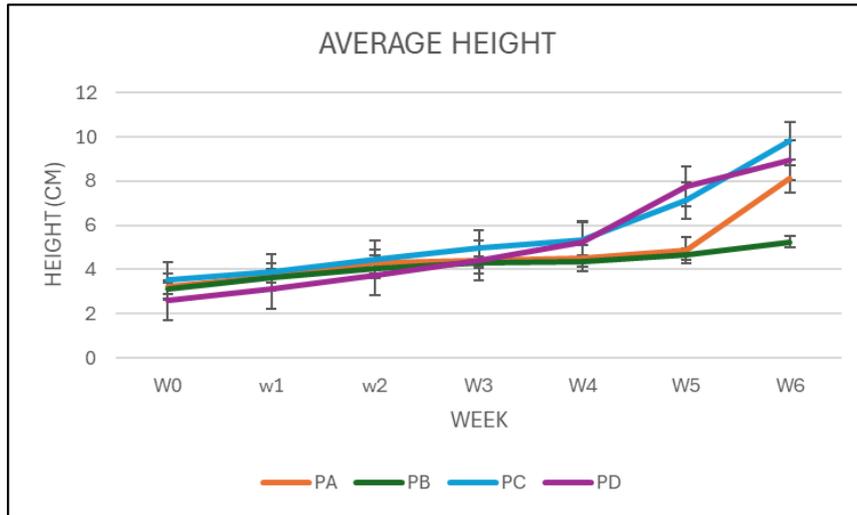


Fig. 3: Graph of the average height of the samples from Week 0 to Week 6

Table 3 Data of the average height of the samples

AVERAGE HEIGHT (CM)							
SPECIMEN	WEEK 0	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6
PA	3.22	3.68	4.32	4.42	4.5	4.88	8.1
PB	3.14	3.66	4.06	4.32	4.38	4.68	5.24
PC	3.52	3.88	4.46	4.96	5.34	7.12	9.83
PD	2.62	3.1	3.74	4.42	5.24	7.76	8.9

All the samples had a similar trend from Week 0 to Week 4, indicating the specimen’s successful growth. There were a few specimens that died during the fifth week, as shown in Fig. 4, which is PA1, PA2, PA3, PA4, and PA5 composition, and it only contains 5 grams of organic coffee materials with no added fertiliser or silica, had the slowest plant growth. This condition may be due to the presence of bioactive compounds in coffee materials that affect plant growth hormones or nutrient absorption. According to Chrysargyris et al. (2020), the use of coffee-based materials in soil can affect plant growth if the material still contains active compounds such as caffeine and polyphenols [8]. Fig. 4 shows the specimens PA1, PA2, PA3, PA5, and PC5, which died after five weeks, and Fig. 5 shows the specimens at Week 6.



Fig. 4: Specimen PA1, PA2, PA3, PA5 and PC5 which died after five weeks



Fig. 5: The specimens at Week 6

3.3 Leaves Count of Plant

Figure 6 and Table 4 below show the graph of the average leaves count of the samples from Week 0 to Week 6 and the data table for the leaves count of each sample.

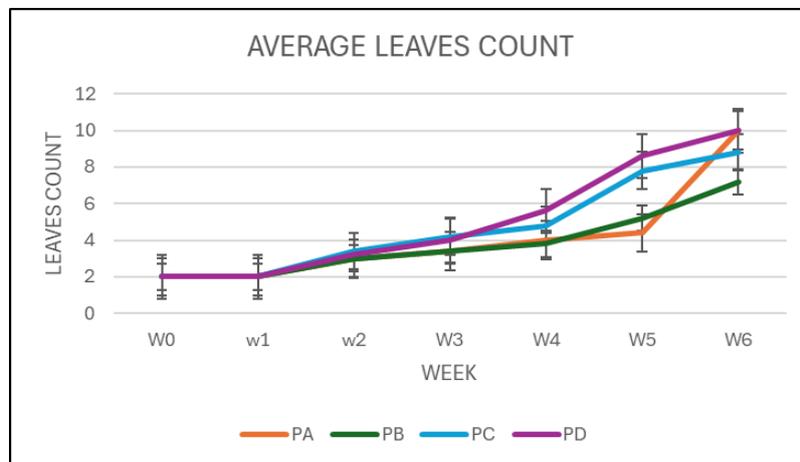


Fig. 6: Graph of average leaves count of the sample from Week 0 to Week 6

Table 4: Data of the average leaves count of the sample

AVERAGE LEAVES COUNT							
SPECIMEN	WEEK 0	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6
PA	2	2	3	3	4	4	10
PB	2	2	3	3	4	5	7
PC	2	2	3	4	5	8	8
PD	2	2	3	4	6	9	10

In Week 4, it shows that PA and PB samples showed a major decrease in leaves while the other samples sprouted new leaves. After Week 5, PD samples had a significant increase in leaves count. PD's specimen which contains 30% of silica in the fertiliser showed a great growth as the sample had the highest leaves count compared to other samples after five weeks of planting. In Week 6, PA shows a sudden increase in leaf count. It is proof that

the addition of silica in the fertiliser promotes the sprouting of new leaves and supports the specimens to grow healthily.

4. Conclusion

In conclusion, the usage of waste from the production of silica water filters for making fertilizers is a sustainable management of waste, which results in the development of important agricultural produce. This process depends on compounding it with other materials likely to complement the silica and effective control of pH and nutrient levels. As this method is friendly to the environment and economical, for it minimizes wastes while coming up with a useful product, it is important that the quality of the fertilizer be checked and tested for quality and nutrient content frequently.

Based on the results discussed, adding silica to the fertilizer promotes the growth of the specimens, which is spinach for this research. It helps the plants to grow higher and sprout more new healthy leaves if compared to the sample with only fertiliser. In addition, the silica was able to fight any fungus and does not attract any pests at all. Furthermore, it does not change the acidity or alkalinity of the soil after being applied three times to the soil.

The method thus reveals a prospect in terms of upscaling for commercialization especially within zones with a high endowment of water treatment industries. However, bear in mind that the local legislation concerning the recycling of wastes and the quality of the fertilizers produced. These specialty fertiliser products could be developed into a more significant part of environmentally friendly farming as the author continues to conduct research on how to improve the effectiveness of the silica filter waste products.

Acknowledgement

The authors would like to express their gratitude to the Faculty of Mechanical and Manufacturing Engineering at Universiti Tun Hussein Onn Malaysia for their help in carrying out this research activity.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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