# Design and Fabrication of Microwave Absorbers Using Water Hyacinth

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***Abstract.*** *Agricultural waste material is produced as a result of an agricultural activity. Water hyacinth is made up of natural compounds. It mainly consists of carbon about 32-35 % by weight. This research has emphasized its eco-friendly nature. Also it has high microwave absorption properties. Samples are fabricated using an agent with water hyacinth to fabricate the proposed absorber. Its performance is determined in terms of its reflection coefficients. It results are compared with that of the commercial microwave absorbers in the frequency range of 0-20 GHz.*

## Keywords:

Microwave absorbers, water hyacinth, reflection coefficient.

## 1. Introduction

At present, electromagnetic waves have many applications in our everyday lives. It can be classified into harmful and harmless electromagnetic waves. Harmful electromagnetic waves have been used in medical and military applications such as X-ray and gamma ray, respectively. Harmless electromagnetic waves are such as microwave and radio wave, for example. Typically, electromagnetic waves can travel through the non-conductive materials which called dielectric materials while electromagnetic waves cannot travel through the conductive materials which called conductor. Non-conductive and electromagnetic shield material can absorb electromagnetic waves. This material called absorber. Most absorbers can absorb the electromagnetic waves in frequency range of 1 – 60 GHz which is the common used in microwave frequency range. Absorbers commercially available nowadays are made from polyurethane and polystyrene containing carbon as the major component and are synthetic materials with a very high price.

Therefore, many researchers studied the use of natural materials as the alternative ways to replace synthetic materials in order to reduce the production cost of absorbers. In 2015, Rajanroop Kaur, Gagan Aul, and Vikas Chawla studied and designed the pyramid shaped absorbers made from the mixture of banana leaves and coal [1]. The dielectric constants of the absorber samples were determined and the samples were investigated by Radar Cross Section method (RCS) compared with commercial synthetic absorbers in frequency range of 0-20 GHz. It was found that the obtained microwave absorbers could reduce reflection in the frequency range of 8.2-12.4 GHz. In 2015, the absorbers from the mixture of dried banana leaves which are the agricultural waste and fine ground coal were investigated and designed. The results showed that these absorbers can reduce the reflection on the average of -45.2 dB in the frequency range of 2-12 GHz.

From these studies, it can be seen that agricultural wastes have been used as a component of absorbers which are the environmental friendly materials and lower production cost compared to commercial absorbers at current [2]. However, agricultural wastes have not been used as the main component in absorbers. Therefore, the researchers want to use the locally available agricultural wastes as the main component of absorbers instead of synthetic absorbers. The agricultural waste we used as the main component of absorbers was water hyacinth. This is because water hyacinth has high carbon component and locally available. The pyramid shaped microwave absorbers from water hyacinth were developed due to the highest surface area of square pyramid shape compared to other geometric shapes. This was for better microwave absorption and easier to install. The microwave absorption of the absorber was investigated by using Vector Network Analyzer and Horn Antenna and the reflection coefficient was determined in the frequency range of 0-20 GHz.

## 2. The Design of the Proposed Absorbers

Design and test of microwave absorber from water hyacinth includes: properties of water hyacinth, designing, molding, and experimental setup for determining microwave absorption of the absorber.

## 2.1 Properties of water hyacinth

Water hyacinth is an alien weed species commonly found in Thailand. The rapid propagation of water hyacinth damages the freshwater ecosystems in Thailand [3]. Water hyacinth is a major invasive plant species and becomes ecosystem problems. The government has been spent the large budget in removing water hyacinth. Currently, there are agencies and organizations help in removing water hyacinth such as use to produce household appliances, feed, compost, etc. Therefore, the researcher suggests that using water hyacinth as the main component of microwave absorber is a way to exploit water hyacinth and reduce the amount of water hyacinth because water hyacinth has carbon as the main component at about 32 – 35% by weight which is suitable to use as the main component of the absorber [3]. Fig. 1 illustrates Water hyacinth.

Fig. 1: Water hyacinth

## 2.2 Design of microwave absorbers

According to studies and articles, microwave absorbers are usually designed into the geometric shape to make it easier for molding. To design the shape of microwave absorber, it must have largest surface area for the highest absorption performance. From the studies, it has shown that the square pyramid shape gives the maximum surface area compared to others. Therefore, the microwave absorbers are compressed into square pyramid shape. The absorber consists of 3x3 square pyramids, 9 square pyramids in total. Total base area is 15 cm x 15 cm, height is 13 cm and contact area excluding base area is 900 $cm^2$ as shown in Fig. 1.

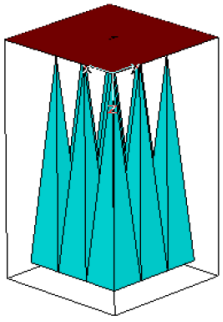

Fig. 2: Square pyramid shaped microwave absorber arranged into 3x3 matrix

The mixing ratio of the main components of a microwave absorber consisted of 80 g of fine ground water hyacinth, 30 g of resin and 1 g solidifying agent. Firstly, resin is mixed with solidifying agent and then the mixture is mixed with fine ground water hyacinth. The mixture of fine ground water hyacinth, resin and solidifying agent is compressed into square pyramid shape using aluminum molds. After the mixture is compressed into compact pyramid shape, let it to dry and remove the molds to obtain one absorber. This same process is used to produce other 8 samples as shown in Fig. 3.

Fig. 3: Square pyramid shaped microwave absorber from water hyacinth arranged into 3x3 matrix

## 2.3 Experimental setup for the determination of microwave absorption

The reflection coefficient of the absorber is determined by using the Vector Network Analyzer was at the frequency range of 0-20 GHz coupled with Horn Antenna above the microwave absorber from water hyacinth on the copper plate. The distance between absorber base and Horn Antenna is 55 cm as shown in Fig. 4.

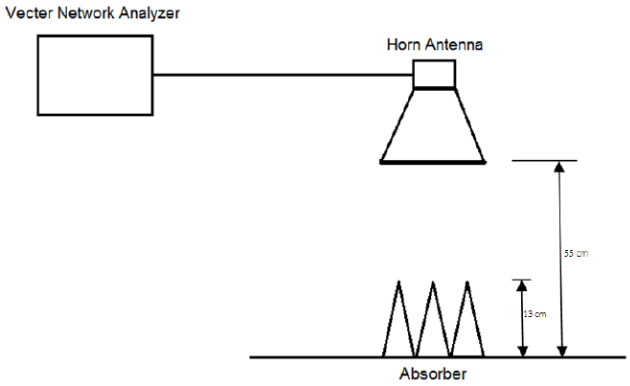


Fig. 4: Experiment setup for determining microwave absorption of absorber from water hyacinth

## 3. Results and Discussions

The reflection coefficients of the proposed microwave absorbers in the frequency range of 0 – 20 GHz are shown in Fig. 5.

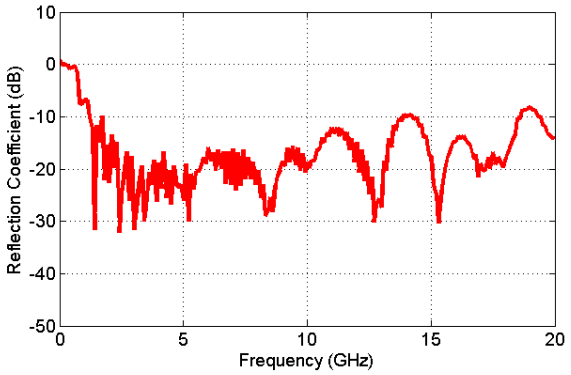


Fig. 5: The reflection coefficients of microwave absorbers made from water hyacinth in the frequency range of 0-20 GHz

Fig. 5 shows the reflection coefficients of microwave absorbers in the frequency range of 0-20 GHz. It can be observed that in the frequency range of 8 – 18 GHz the reflection coefficient is lower compared to other frequency ranges. The lowest reflection coefficient is about -30 dB and the highest reflection coefficient is about -10 dB.

To evaluate the absorption efficiency of the proposed absorber, the efficiency of the commercial absorber is determined and compared to the proposed absorber. Fig. 6 shows the commercial microwave absorber.

Fig. 6: The commercial microwave absorbers

The commercial microwave absorber is investigated by using the same method and the results are shown in Fig. 7. Fig. 7 shows the reflection coefficients of commercial microwave absorbers in the frequency range of 0-20 GHz which is the same range we used to study the microwave absorber made from water hyacinth. It is found that the lowest reflection coefficient of commercial microwave absorber is about -39 dB and the highest reflection coefficient is about -10 dB.

The comparison of reflection coefficients of microwave absorbers made from water hyacinth and commercial materials is shown in Fig. 8.

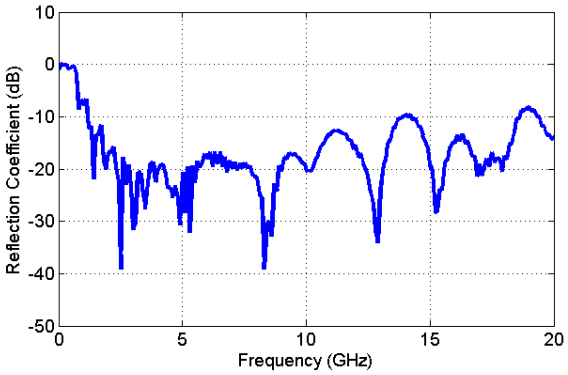


Fig. 7: Reflection coefficient of commercial microwave absorber in the frequency range of 0 – 20 GHz

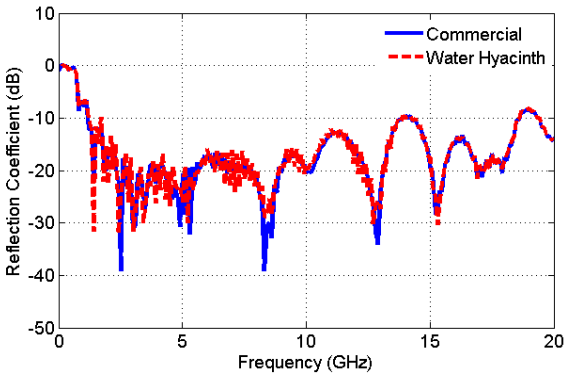


Fig. 8: Comparison of the reflection coefficients of both microwave absorbers in the frequency range of 0 – 20 GHz

Fig. 8 shows the comparison of the reflection coefficient of microwave absorbers made from water hyacinth and commercial materials in the frequency range of 0-20 GHz. In the frequency range of 8-18 GHz, it is found that the lowest reflection coefficient of commercial microwave absorber is about -9 dB lower compared to microwave absorber made from water hyacinth while the highest reflection coefficients of both absorbers are the same of about -10 dB.

## 4. Conclusions

The microwave absorber made from water hyacinth in this study can absorb microwave as the microwave absorber made from commercial material. The highest reflection coefficient of -10 dB is found in the frequency range of 8-18 GHz. The absorber in this study can be used as the microwave absorber due to low reflection coefficient which indicates that this microwave absorber can effectively absorb microwave. Therefore the microwave absorber from water hyacinth can be used in replace of commercial microwave absorber in the frequency range of 8-18 GHz.

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