STUDY ON THE POTENTIAL TO ABSORB HEAVY METAL (FE, CU, MN) IN CONTAMINATED WATER BY *Centella asiatica*

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SUMMARY

Centella asiatica has advantages in heavy metals treatment in soil and water. In Vietnam, native plants have the ability to treat environmental pollution very well. Numerous studies have demonstrated the ability of *Centella asiatica* to handle heavy metals in soil. However, the research team wanted to confirm their adaptability in the water. This study carried out the potential to absorb some heavy metals as Fe, Cu, Mn by using *Centella asiatica* and showed the remarkable results. When the heavy metal concentrations were changed, the removal efficiencies also were changed respectively. This research conducted to analyze heavy metal concentration in contaminated water by method UV-VIS and in vegetable by method Atomic Absorption Spectroscopy (AAS). The highest amounts of Fe, Cu and Mn found in vegetable were 9 mg/kg, 15 mg/kg and 3 mg/kg, respectively. During the development, the *Centella asiatica* turned increase the pH level, helped the solids settle more quickly and increased the heavy metal treament efficiencies. In all of experiment steps, there was no addition any nutrition for support the *Centella asiatica* growing. Therefore, this was a new trend to continuously research the potential to treat heavy metal in water using Phytoremediation (Phytoremediation technologies use plants to treat hazardous contaminants in soil, air, and water).

Keywords: Bioremediation, *Centella asiatica*, environmental biotechnology, heavy metal, Phytoremediation.

1. INTRODUCTIONS

Centella asiatica, commonly known as Indian pennywort, Asiatic pennywort or goyu kola is a herbaceous, frost-tender perennial plant in the flowering plant family Apiaceae. It is also knew as medicinal ingredient has been widely used in folk medicine for hundreds of years to treat a wide range of illness (Brinkhaus el at., 2000). It is used in different continents by diverse ancient cultures and tribal groups. It is distributed in many Asian countries, such as Japan, India, China, Indonesia and Sri Lanka (Brinkhaus et al., 2000). The parts of *Centella asiatica* plant are used for medicinal purposes and they can be harvested throughout the year (Zainol et al., 2003). In South Africa, it is caused to treat leprosy, wounds, cancer, fever and syphyllis, while in Europe; the *Centella asiatica* essence is extracted for using for many years to treat wounds (Oyedeji and Afolayan, 2005). Nowadays, *Centella asiatica* is commercially available in the markets and pharmacies in the form of edible products such as *Centella asiatica* juice can drinks, capsule form and cosmetic products such as shampoo, soap and shower foam (Schaneberg et al., 2003). Furthermore, *Centella asiatica* has the ability to accumulate heavy metals in contaminated water, but has not yet been reported much in the literature. Therefore, this study aimed to determine the metals accumulation of *Centella asiatica* or its ability of exist in the water environment contaminated by heavy metals as Fe, Cu and Mn.

A contaminated water treatment process by the use of plants is called Phytoremediation. Phytoremediation has also been called green remediation, botano-remediation, agro remediation and vegetative remediation (Erakhrumen, 2007). G.H. Ong has evaluated and showed a relatively good result when using *Centella asiatica* to treat heavy metals in soil (G.H. Ong, 2011). Hamizah Mokhtar have carried out her study on removal of Copper in contaminated water of solution containing 1.5 mg/L, 2.5 mg/L and 5.5 mg/L of Copper (Hamizah Mokhtar, 2011). The results showed the maximum removal of copper in the solutions containing Centella Asiatica was 99.6% as compared to 97.3% in solutions containing Eichhornia crassipes. In Vietnam, Phuong has investigated *Centella asiatica* was very effective in removing Asenic (Nguyen Thi Kim Phuong, 2008).

2. RESEARCH METHODOLOGY

The study conducted the experiments in the tanks (10 litre), and weighing exactly 300g *Centella asiatica* into put in each tank, that plants being similarly determined in terms of biomass and the morphology in the experimental terms was the same. These plants were put in a hydroponic system containing tap water, for a four-week acclimatization period, before being exposed to heavy metal contaminants. The experimental conditions were kept in sunlight places for naturally growing. Additional, the study also carried out the control experiments to examine the metal concentration fluctuations without *Centella asiatica* and the adaptation level of *Centella asiatica* in clean water compare to in contaminated water by heavy metals.

Fig. 1. Centella Asiatica plant setup

The study used distilled water for experiment performance to avoid possible contamination. The heavy metal concentrations as Fe, Cu, Mn were showed in Table 1 for a period of 15 days only (because the lacking of nutrition). The development process of *Centella asiatica* was monitored every day such as: fallen leaves, water pH, and the volume of the water and so on. The sampling period was conducted every 5 days, 10 days and 15 days.

The concentration of heavy metal accumulation in vegetables was analyzed at the time as the most growing of trees. The control tank has highest heavy metal concentration without *Centella asiatica.*

Table 1. The concentration of heavy metal in tanks with *Centella Asiatica*

Name	**Tanks of Cu**				
	Cu8	Cu16	Cu24	Cu32	Cu-MT
Conc. (mg/L)	8	16	24	32	24
Name	**Tanks of Mn**				
	Mn4	Mn8	Mn12	Mn16	Mn-MT
Conc. (mg/L)	4	8	12	16	12
Name	**Tanks of Fe**				
	Fe20	Fe40	Fe60	Fe80	Fe-MT
Conc. (mg/L)	20	40	60	80	60

MT: Blank sampling site (Quality assurance/quality control)

The analysis methods: Copper concentration was analyzed by titration following Standard Methods for the Examination of Water and Wastewater of American Public Health Association. Iron concentration was analyzed by Spectroscopy using Othor Phenalthroline (TCVN 6177-1996); Manganese concentration was analyzed by Spectroscopy using formaxim as an oxidant (TCVN 6002-1995). The heavy metal concentrations in *Centella asiatica* were analyzed by AAS.

The plants were washed with distilled water, excess water was allowed to drain off and the plants were cut and weighed. Subsequently, the plant was dried in the oven for 24 hours at 25^0C - 35^0C, for preparation to ascertain the accumulation of heavy metal of each sample. All sample preparation processes followed QCVN 40-2015 (Vietnam National Quality of wastewater industry).

3. RESULTS AND DISCUSSION

In the process of metabolizing substances by plants may undergo some major processes, namely: transformation, absorption, mineralization and root-zone fixation. These processes are imaged generally by fig. 2:

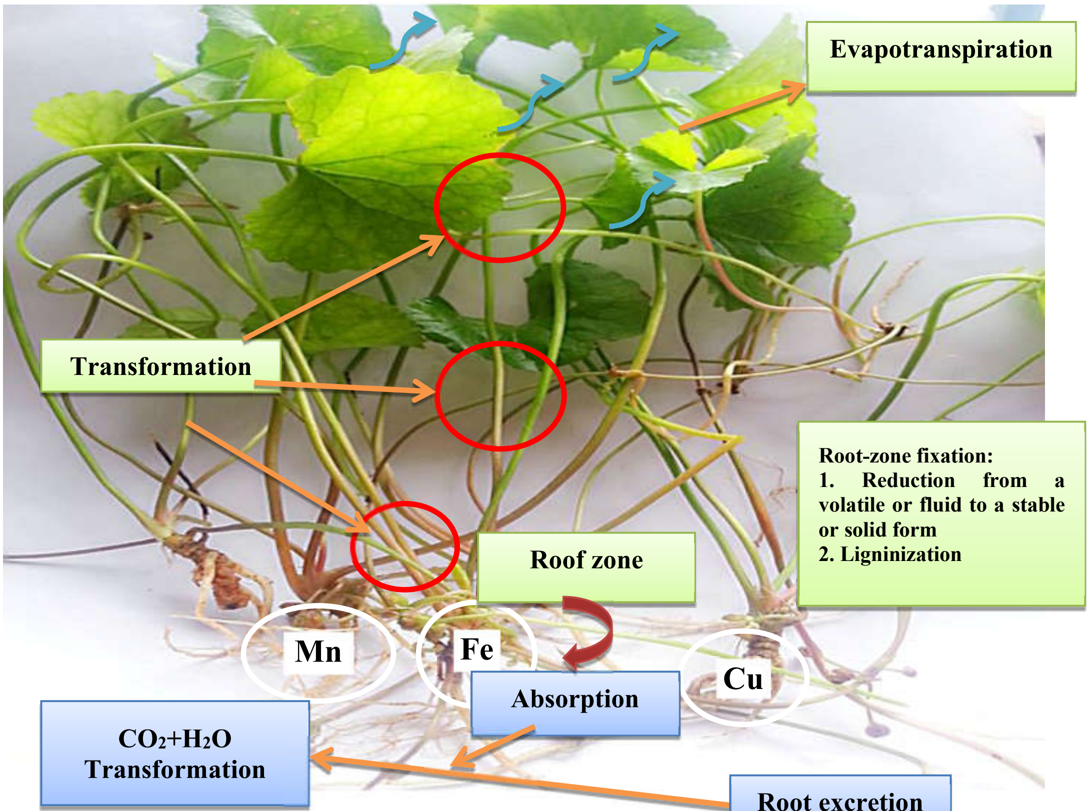

Fig. 2. Centella asiatica's absorption and metabolism mechanism heavy metal

3.1. The fluctuations of the heavy metal concentrations of water samples with *Centella asiatica*

After 5 days, *Centella asiatica* plants developed well, starting to appear new stems. However, after the 10^{th} day, the development process slowed down, starting to appear yellow leaves. In comparison with the control samples and blank samples, the phenomenon of their biomass changes was relatively similar. Hence, there was a sign to show *Centella Asiatica* adapted well and being an indicator of the environment.

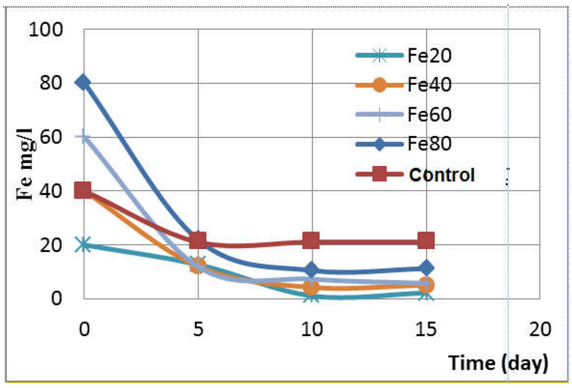

Fig. 3. The fluctuations of Fe concentrations over time

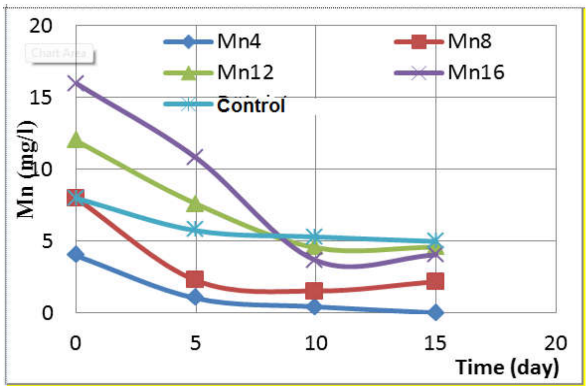

Fig. 4. The fluctuations of Mn concentrations over time

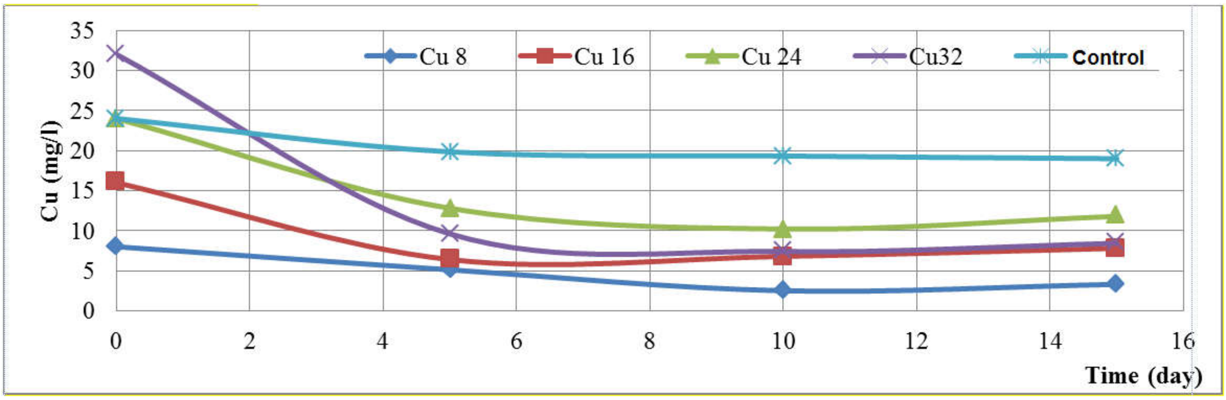

Fig. 5. Fluctuations of Cu concentrations over time

The above figures show the heavy metal accumulation is relatively remarkable. The concentrations of Fe, Cu, Mn were decreased significantly. From Figs. 3, 4 and 5, they show the best heavy metal accumulation efficiency after 10 days. This can be explained that *Centella asiatica* is a herbaceous plant, short-term life, hence after 10 days, the plant's growth ability decreased (a partly also due to water during the experiment has no nutrient supplied to the plant). At this time, the *Centella asiatica* trees started to appear some yellow leaves. This is an important reason due to the metal contents slightly increased back in the water, reducing the processing efficiency. Moreover, the amount of metal accumulated in the tree has saturated. The topic will address this issue when assessing the amount of metal accumulated in vegetables. The results also show that depending on the dosage in the wastewater, the heavy metal treatment efficiencies were different. The treatment process was implemented through two ways of accumulation as in the plants and in the precipitation by the ability to change the pH of the water of *Centella asiatica*.

3.2. Fluctuations of pH level

The experimental samples were monitored continuously during the planting time, pH values ranged from 5 to 6 and not much variation. However, after 7 days, pH has a trend increased from 7 to 8.2 while the pH was almost unchanged in the experiment no vegetables, only ranged from 5 to 6. At the same time, comparing with the original water sample, the sediment content increased significantly in the tanks with vegetables. The precipitation has color as the characteristic color of the metals. While the no vegetable tank has clear color of original water and less sediment content. This proves that the process of growing of Centella Asiatica in the water drove an increase of the pH of the water through the metabolism and growth of the plants. Thus, it can be seen that *Centella* *asiatica* has ability to increase pH in heavy metal treatment without using any chemical compound, to help minimizing economic and secondary pollution.

3.3. Contents of Fe, Cu and Mn in *Centella asiatica*

The study carried out to examine heavy metal contents in some *Centella asiatica* plants to assess the accumulation. The results showed the contents of Fe, Cu and Mn in *Centella asiatica* are 3 mg/kg, 1 mg/kg and 0.08 mg/kg, respectively (Table 2).

Table 2. Contents of Fe, Cu and Mn in Centella asiatica after 10 days

	Name	Contents of heavy metal in water (mg/l)	Contents of heavy metal in *Centella asiatica* (mg/kg)	Rate of metal increase in *Centella asiatica* (times)
Iron	Initial *Centella asiatica* sample		1.1	
	Fe20	20	5.5	4.4
	Fe40	40	8.5	7.4
	Fe60	60	9.7	8.6
	Fe80	80	9.9	8.8
Copper	Initial *Centella asiatica* sample		3.05	
	Cu8	8	8	1.6
	Cu16	16	11.3	2.7
	Cu24	24	15.1	4.0
	Cu32	32	15.2	4.0
Manga-nese	Initial *Centella asiatica* sample		0.08	
	Mn4	4	1.4	16.5
	Mn8	8	2.6	31.5
	Mn12	12	3.0	36.5
	Mn16	16	3.2	39.0

The absorbed and mineralized heavy metal contents become saturated when reached to a certain concentration threshold (Table 2). For Iron, although the concentration was up to 80 mg/l, the amount of absorbed iron was only about 9 mg/kg; about 15 mg/kg and 3.2 mg/kg for Cu and Mn, respectively. If compared with the waste water standard QCVN 40-2011 column B (the content of Fe, Cu, Mn are 5 mg/l, 2 mg/l, 1 mg/l respectively), so the ability to accumulate these metals of *Centella asiatica* in this study is higher than the pollution threshold of wastewater, hence this is a potential in the heavy metal treatment in industrial wastewater. Also Table 2 shows that the accumulation capacity of Cu is greater than that of Fe in the water. We can also see that the accumulation capacity in the vegetables becomes saturated, with Fe stable at about 9 mg/kg; with copper at about 15 mg/kg; with Mn at about 3 mg/kg, when reached to a certain threshold.

3.4. Evaluation of the heavy metals treatment efficiency by *Centella asiatica*

The ability of heavy metal treatment process in polluted water applies Phytoremediation method using *Centella asiatica*, is followed by two mechanisms: The first one is the metal will be absorbed directly into the stem, roots and leaves. The second one is *Centella asiatica* helps to increase the pH level of the water naturally. The results are showed in Table 3.

Table 3. Performance of treatment heavy metals in water by Centella asiatica after 10 days

Name	Total efficiency (%)	Accumulation efficiency in *Centella asiatica* (%)	Efficiency due to pH variation (%)
Mn4	88.9	33.0	55.9
Mn8	80.8	31.5	49.3
Mn12	62.1	24.3	37.8
Mn16	61.8	19.5	42.3
Control	**33.7**		**33.7**
Fe20	94.6	22.5	72.2
Fe40	89.4	18.8	70.6
Fe60	87.9	14.5	73.4
Fe80	86.9	11.1	75.7
Control	**47.3**		**47.3**
Cu 8	68.8	62.5	6.3
Cu 16	57.5	51.9	5.6
Cu 24	57.5	50.4	7.1
Cu32	53.8	38.1	15.6
Control	**19.5**		**19.5**

The Table 3 shows that the iron treatment efficiency is the best, the its overall treatment efficiency is up to 94.6% if the initial concentration is 20 (mg/l), but when the concentration of Fe is increased to 80 mg/l, the efficiency is only 86% and remains at a stable level due to the ability to accumulate metal reaches to the limitation of saturation. Similarly for Manganese and Copper, the processing efficiencies are decreased when the heavy metal concentrations increase. The Table 2 shows that the overall treatment efficiency of Copper is not as high as of Fe, but the absorbed copper content in vegetables is highest and reaches 62.5% at a concentration of 8 mg/l, when the concentration of Cu was increased in water up to 32 mg/l so the cumulative efficiency in *Centella asiatica* still reached to 38.1%.

4. CONCLUSION

With the research results, it has been proven once again the ability to treat polluted water using friendly environmentally biological methods. As a reason, the treatment of pollutants is much simpler and less expensive than chemical and physical methods. *Centella asiatica* is a kind of living in the soil, but when grown in water, it is highly adaptive. In this study shows that after 10 days, *Centella asiatica's* metal processing started to stabilize. The Iron accumulation capacity can reach over 9 mg/kg, Cu can reach above 15 mg/kg and Mn can reach over 3 mg/kg. This is in a condition that no any nutrients provided to trees. The ability accumulation of *Centella asiatica* with Cu is biggest (equal 62.5%) compared to Mn (equal 30%) and Fe (equal 22.5%). In addition, *Centella asiatica* also helps to create conditions to increase the pH of the water, which is an important condition for metal treatment processing in the limited financial investment and also reducing secondary pollution. This study recommends a deeper research to achieve further results ensuring the ability of *Centella asiatica* to treat wastewater containing heavy metals in the future by nutrient providing and planting directly in wastewater.

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NGHIÊN CỨU KHẢ NĂNG HẤP THỤ KIM LOẠI (Fe, Cu, Mn) TRONG NƯỚC CỦA CÂY RAU MÁ (*Centella asiatica*)

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TÓM TẮT

Sử dụng thực vật để xử lý nước và nước thải là một trong những phương pháp xử lý thân thiện với môi trường. Hơn nữa, xử lý chất thải trong cơ chất dễ dàng hơn trong nước thải. Hiện nay tại Việt Nam các loài cây bản địa có khả năng xử lý ô nhiễm môi trường rất tốt. Trên cơ sở đó đề tài nghiên cứu khả năng hấp thụ một số kim loại Fe, Cu, Mn của cây Rau Má, kết quả cho thấy tương đối khả quan. Khi thay đổi những nồng độ khác nhau của các kim loại thì hiệu suất xử lý cũng thay đổi theo hướng tích cực. Khả năng tích lũy trong cây rau lần lượt đạt: Fe có thể đạt trên 9 mg/kg, Cu đạt trên 15 mg/kg và Mn đạt trên 3 mg/kg. Khả năng của cây rau Má với mẫu chứa Cu lớn hơn mẫu chứa Fe và lớn hơn mẫu chứa Mn. Quá trình trồng cây còn góp phần làm tăng pH, giúp cho quá trình tạo cặn lắng nhanh hơn, điều này làm tăng khả năng xử lý kim loại trong nước. Kết quả nghiên cứu còn tạo điều kiện mở ra tiềm năng mới cho việc sử dụng thực vật trong xử lý nước thải.

Từ khóa: Công nghệ sinh học môi trường, kim loại nặng, rau má, xử lý kim loại bằng thực vật.

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