Research and select some plants that can absorb heavy metals (Pb, Ni, Cd) in trade village wastewater Trieu Khuc, Hanoi

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Abtract

The pollution of trade villages, especially pollution of water environment, is a difficult and inadequate problem and has not been able to find a definitive treatment method. The water sources in trade villages is under to serious pollution due to the large amount of the waste from living activities, industrial production and handicrafts industry is almost untreated and discharged directly into the canal system. The purpose of this paper is to study and selection of aquatic plants able of absorbing heavy metals (Pb, Ni, Cd) in the trade village wastewater Trieu Khuc, Hanoi. The analytical results showed that after 30 and 60 days of testing, the content of three metals in the original wastewater sample was significantly reduced compared to the control sample and lower than the allowable value of Vietnamese Standard 40:2011/MONRE - National technical standards on surface water quality. The accumulation of all three metals Pb, Ni, Cd in the water spinach (*Ipomoea aquatica*) is higher than the Cilantro (*Enydra fluctua*): the Pb content accumulates in the Cilantro and the water spinach after 30 and 60 days respectively, 2.013; 2.040 mg/ kg DW and 6.163; 5.881 mg/kg DW; Similarly, the Ni content is 43.76; 56.69 mg/kg DW and 30.19; 43.72 mg/kg DW; Cd content is 1.708; 3.026 mg/kg DW and 0.367; 0.617 mg/kg DW. The content of heavy metal in the roots is higher in the stem many times and the treatment efficiency for Ni is the highest (88.89%) and Pb is the lowest (25.73%).

Keywords: aquatic plant, heavy metal, pollution, trade village, waste water.

1. Introduction

According to the data from a survey report of the Ministry of Natural Resources and Environment, currently, Viet Nam has more than 1,300 trade villages recognized and 3,200 trade villages with operating, contributing to socio-economic development in localities. However, the environmental pollution is quite serious because most trade villages do not have suitable planning, small production scale, outdated technology, patchy, the labor qualification is low etc... in which the pollution of waste water is more alarming (Chu, 2010). The environmental pollution in the trade villages is characterized by scattered pollution within an area (hamlet, village, commune ...) and directly affecting the water, air and soil environment in the area. The survey results of 52 typical trade villages in the country showed that 46% of trade villages have heavily contaminated environments (for air, water, soil or all three forms), 27% of medium pollution and 27% slight pollution (Chu, 2010).

Trieu Khuc trade village (Tan Trieu commune, Thanh Tri district, Ha Noi city) has been famous for along time with many traditional jobs such as: making feathers, weaving brocade, making fibers, collecting and recycling waste plastic. According to data of Tan Trieu Commune People's Committee, Trieu Khuc trade village has 298 households with a total of 13,976 workers and an income of about 30 million VND /person/year. The multi-occupation in the trade village is the main reason for the heavily contaminated environment here. Every day, the trade village discharges to the environment nearly 10 tons of waste and thousands of cubic meters of waste water without any treatment system. The canal runs from the trade village to the fields has characteristic of black colours, filled with floating garbage, stinking because it is a "gathering place" of feather wash or waste products of plastic recycling (Chu, 2010).

Accompanied by economic growth is an increase in environmental pollution, the pollution level of the trade villages does not only no decrease but also tends to increase, almost of the monitoring indicators exceed the permitted level many times and there is no appropriate treatments. The currently applied wastewater treatment methods have quite complex technology and high processing efficiency but are quite expensive. The contaminated wastewater treatment with ecological technology has been concerned in recent years because of its environmental friendliness, simplicity, ease of deployment and low cost. According to Majeti et al (2003), there are about 400 types of plants that has capable of accumulating heavy metals in the world. In Vietnam, some authors have demonstrated by experiments the important role of some aquatic plants such as: corn and elephant grass (Dong et al, 2008), aromatic plants (Diep, 2003), water spinach and wild goose (Vu et al, 2015), duckweed, reed, Vetiver grass (Vu et al, 2015)… capable of removing heavy metals (Mn, Pb, Ni, Cr) as well as some organic pollutants (N, P, COD...) from industrial wastewater, domestic wastewater and eutrophic water. The purpose of this study is to survey and select some of aquatic plants capable of absorbing heavy metals (Pb, Ni, Cd) including: cilantro (*Enydra fluctuans*), water hyacinths (*Eichhornia crassipe*s) and water spinach (*Ipomoea aquatica*) in trade village wastewater Trieu Khuc, Hanoi

2. Material and method

2.1. Set up experiment

The sample of contaminated wastewater in the Trieu Khuc trade village, Hanoi and three type of aquatic plants is the cilantro (*Enydra fluctuans*), the water hyacinths (*Eichhornia crassipe*s) and the water spinach (*Ipomoea aquatica*) which is growing in uncontaminated water bodies collected randomly in Hanoi. Every plant is grown separately in tanks containing of 100 liter contaminated wastewater. Monitoring the growth and development of plants on the contaminated water medium through parameters such as: height, number of shoots, ratio survival/death of plants in 3 weeks. The total heavy metal content of the three plants will be analysis at D0, D30 and D60 days according to the experimental period.

2.2. Method of analyzing heavy metal content

Aquatic plant sample: rinse soil cleanly, roots and stems + leaves are separated, then cut into small pieces, dry absolutely at $105^0C/24h$, final grind into powder. Water samples were collected at the same time with plant samples and compared with the control samples (samples taken directly at waste water drainage channels of trade villages). Analysis the total content of heavy metal: weigh about 1 g of sample, heat the sample with a mixture of 8ml of HNO_3 and 1.5 ml of $HCLO_4$ acid for 2 hours, parallel to the blank sample. Samples were analyzed by flame atomic absorption spectroscopy (AAS) method at optimal absorption wavelengths for each element at the National Institute of Agricultural Planning and Projection, 61 Hang Chuoi, Ha Noi city.

2.3. Calculation of BCF

Bioconcentration Factor is the ratio of the heavy metal concentration in an plant to the heavy metal concentration in the water environment (Arnot J.A and Gobas F.A, 2006):

$$BCF = C_B/C_W$$

where BCF - Bioconcentration Factor is calculated by experimental data, the value of coefficient calculated in dry weight; C_B is the heavy metal concentration in plant (mg/kg dry weight); C_W is the heavy metal concentration in the water (mg/L).

2.4. Statistical analysis

All experiments were done in triplicate and the data were calculated and drawn by the software GraphPad Prism 6 (one-way ANOVA). Statistical significance was accepted at a level of $p < 0.05$.

3. Results and discussion

3.1. The surveying results of biological parameters

After 03 weeks of growing on contaminated wastewater from the Trieu Khuc trade village, Hanoi. The survival rate of all aquatic plants is varied from 80 to 90%, however, the growing rate of the water hyacinth (*Eichhornia crassipes*) is very slow and the new shoots appear very little. Results of surveying of biological parameters are shown in Table 1 and Figure 1.

Table 1. Results of survey of biological parameters

	Time	Water spinach	Water hyacinth	Cilantro
Growing rate (cm)	Initial	12.5	5.5	10.8
	03	32.6	7.25	35.7

	weeks			
	Ratio	2.61	0.04	3.3
Ratio of survival (%)	03 weeks	86	85	80

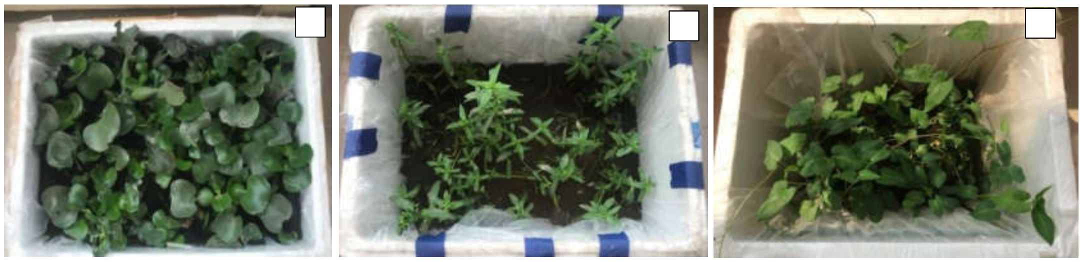

Figure 1. The water hyacinth (*Eichhornia crassipe*s, a), cilantro (*Enydra fluctuan,* b) and water spinach (*Ipomoea aquatica,* c) is growing on contaminated wastewater medium after 3 weeks.

From these results, it could be seen that the water spinach (*Ipomoea aquatica*) and the cilantro (*Enydra fluctua*) has the highest survival and growth rate and were selected to study and monitor their heavy metal adsorption efficiency in 60 days.

3.2. The capacity of heavy metal adsorption Pb, Ni and Cd

To determine the capacity of heavy metal adsorption (Pb, Ni and Cd) of water spinach (*Ipomoea aquatica*) and the cilantro (*Enydra fluctua*), the research team had put two aquatic plants in the wastewater medium that is collected from the drainage canal of the Trieu Khuc trade village, Hanoi. All of the initial three heavy metal content in waste water sample in trade village is exceed the Vietnamese Standard 08:2015/MONRE (column B), as follows: Ni (0.27 mg/kg) exceed 2.7 times; Pb (2.829 mg/kg) is 56.58 times and Cd (0.517 mg/kg) is 51.7 times. The wastewater samples and aquatic plant samples were collected and analyzed at the same time (D30 and D60). After 60 days of experiment period, the growth rates of the two plants are relatively uniform. The heavy metal content accumulated in the two aquatic plants is different each other. After 30 and 60 days, the content of Pb, Cu, Cd accumulated in the parts of the aquatic plant is shown in Table 2 and Figure 2.

Table 2. Variation of the total heavy metal content in aquatic plant samples (exposed with the waste water of trade village) and control samples

Speci es of plants	Med ium	Pb (mg/kg dry weight)			Ni (mg/kg dry weight)			Cd (mg/kg dry weight)		
		I nitial	0 days	0 days	nitial	0 days	0 days	nitial	0 days	0 days
Cilant	Cont	2								

ro (*Enydra fluctua*)	rol	.829		.728	.01	.27	.024	.001	.517	.18	.01
	Experiment-roots	.448	3	.518	.001	1.04	6.69	3.01	.319	.361	.393
	Experiment-stems	.766	(	.142	.518	.55	0.46	3.37	.025	.171	.32
	Experiment-leaves	.186	(	.353	.522	.31	6.61	0.31	.022	.176	.313
Total content		.4	4	.013	.040	6.9	3.76	6.69	.366	.708	.026
Water spinach (*Ipomoea aquatica*)	Control	.829	2	.27	.01	.27	.012	.01	.517	.27	.01
	Experiment-roots	.616	5	.874	.001	.23	3.55	1.68	.034	.089	.139
	Experiment-stems	.627	(	.676	.736	.88	.00	.89	.023	.206	.378
	Experiment-leaves	.589	5	.613	.145	.44	.64	3.15	.024	.072	.1
Total content		1.832	1	.163	.881	4.55	0.19	3.72	.081	.367	.617

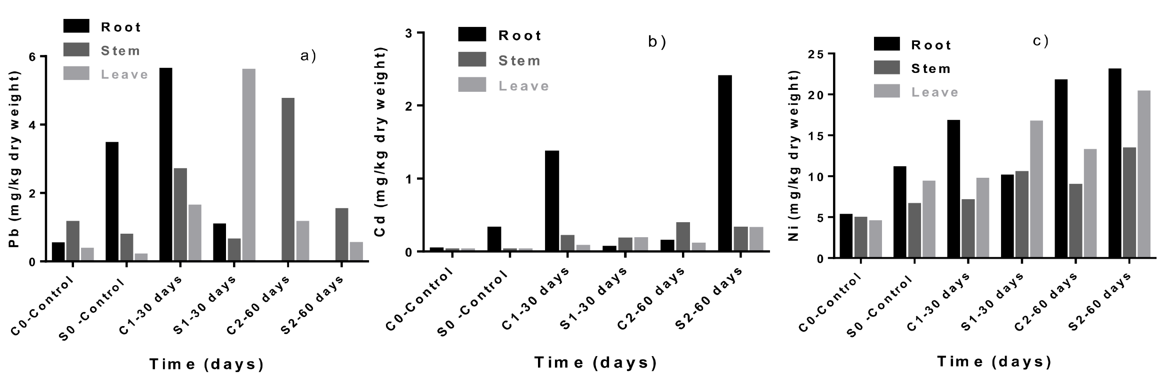

Figure 2. The content of Pb (a), Cd (b) and Ni (c) in the parts of the aquatic plant varied to time (Control - the first day, 30 and 60 days), where is: C- code for the Cilantro plant and S - code for the Water spinach.

The content of heavy metals accumulated in the stem, root, leaf of the water spinach (*Ipomoea aquatica*) and the cilantro (*Enydra fluctua*) tends to increase over time. All three metals was accumulated in the roots is the highest, next the stems and leaves. Particularly, Pb metal in Water spinach (*Ipomoea aquatica*) tends to accumulate in the stem higher than in the roots and leaves from 4 to 47 times, in the Cilantro (*Enydra fluctua*) is from 1.5 to 15 times. At the last day of the experimental period, the accumulation rate in root/stem/leave is lowest for Cd metal and highest for Ni. The treatment efficiency of Pb, Ni and Cd in wastewater calculated by analyzing the content of metals in the environment before and after planting. The results are shown in Table 3 and Figure 3.

Table 3. Variation of the total heavy metal content in water samples (before and after planting)

Samples	Pb (mg/kg dry weight)			Ni (mg/kg dry weight)			Cd (mg/kg dry weight)		
	nitial	0 days	0 days	nitial	0 days	0 days	nitial	0 days	0 days
Cilantro	.829	.728	.01	.27	.024	.01	.517	.18	.01
Water spinach	.829	.27	.01	.27	.012	.01	.517	.27	.01

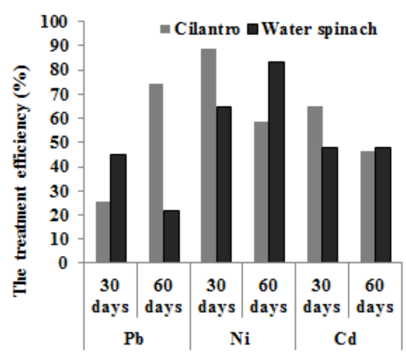

Figure 3. Percentage of content (%) Pb, Ni, and Cd is removed from the waste water

Figure 3 shows the percentage of heavy metal content removed from the contaminated wastewater after 30 and 60 days of experimental planting. The percentage of heavy metal content in the waste water was planted with the Cilantro higher than the Water spinach. The content of Ni removed from the waste water with the Cilantro is the highest (88.89%) and Pb is the lowest with 25.73%. The correlation between uptake and elimination process of heavy metal in aquatic plants is shown by the bioconcentration factor (BCF). The higher the coefficient, the greater the efficiency of processing. The bioconcentration factor of the water spinach (*Ipomoea aquatica*) and the cilantro (*Enydra fluctua*) has increased over time (Table 4).

Table 4. Bioconcentration after 30 and 60 days

Species of plants	**Bioconcentration (BCF)**					
	Pb (BCF-1)		**Ni (BCF-2)**		**Cd (BCF-3)**	
	30 days	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Cilantro	2.76	204.01	1823.33	5669	9.49	302.6
Water spinach	4.85	588.11	2515.83	4372	1.36	61.7

Results in Table 3 showed that, in both period, the accumulation of Pb, Cd and Ni in the Cilantro (Enydra fluctua) is higher in the water spinach (Ipomoea aquatica). Our results are in agreement with these previous studies (Dong et al, 2008; Truong et al, 2010; Le, 2009; Tran, 2004), the authors showed that aquatic plants tend to accumulate heavy metals in roots more than stems and leaves, some heavy metals less toxic to plants should be transported from the roots to the stems, leaves and accumulated in the stem at high concentrations without effecting to the development of plants (Roger D.Reeves and Alan J.M.Baker, 2000). The water spinach (Ipomoea aquatica) and the cilantro (Enydra fluctua) are capable of adapting and developing well in the environment of waste water, the content of three heavy metals in the waste water lower than the allowable value of Vietnamese Standard 40:2011/MONRE - National technical standards on surface water quality (Dong et al, 2008; Truong et al, 2010). These observations can regard as direct evidence to support the hypothesis that using aquatic plants - phytotechnology- to treat pollution in sediment, soil and water for reducing the risks to environment and human health in the trade villages and in other water bodies.

4. Conclusion

The research results give some conclusions as follows:

The Cilantro (*Enydra fluctua*) and the water spinach (*Ipomoea aquatica*) can live and develop normally within the waste water in which contaminated with heavy metals (Pb, Ni, Cd) from Trieu Khuc trade village, Hanoi. The growth rate on the contaminated environment of the two plants is quite fast, the biomass of the water spinach is higher than the Cilantro.

The accumulation of all three metals Pb, Ni, Cd in the water spinach (*Ipomoea aquatica*) is higher than the Cilantro: the Pb content accumulates in the Cilantro and the water spinach after 30 and 60 days respectively, 2.013; 2.040 mg/ kg DW and 6.163; 5.881 mg/kg DW; Similarly, the Ni content is 43.76; 56.69 mg/kg DW and 30.19; 43.72 mg/kg DW; Cd content is 1.708; 3.026 mg/kg DW and 0.367; 0.617 mg/kg DW.

The content of heavy metal in the roots is higher in the stem many times, particularly, Pb metal in Water spinach (*Ipomoea aquatica*) tends to accumulate in the stem higher than in the roots and leaves from 4 to 47 times, in the Cilantro (*Enydra fluctua*) is from 1.5 to 15 times. The treatment efficiency for Ni is the highest (88.89%) and Pb is the lowest (25.73%).

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