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Effect of using Cyperus Alternifolius to improve water quality of Nhue river

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Abstract

This study investigated the ability of Cyperus Alternifolius improving water quality of Nhue River was studied in a laboratory experiment. The samples of water, sediment and plants were analysed for N, P and heavy metals (Fe, Pb, Cd, and Zn). During the time of experiment, C. Alternifolius have grown well in all experimental tanks. At the end of experiment (14 days), analysis results showed high levels of N, P and heavy metals in the tissues of C. Alternifolius.
There were 2,5 ÷ 5,5% of TN and 4,5 ÷ 5,9% of TP increment in the tissues of C. Alternifolius. Cd and Hg contents were not detected in the tissues at the beginning of the experiment, however, a significant content were detected at the end. Zn and Fe content had increased 19,6 to 48 and 23 to 50 times, respectively. These results indicate the suitability of using Cyperus Alternifolius to improve water quality of Nhue river.

Keywords: Nhue river; Cyperus Alternifolius; water quality.

1. Introduction

Nhue River is a tributary of Nhue Day River system with a length of 72 km, originates from the Red River at Lien Mac - Tu Liem and flows through nine districts of Hanoi and Ha Nam, finally flowing into the Day River at Hong Phu bridge in Ha Nam Province.

Nhue River basin has a great diversity of species, with 36 species of aquatic plants, 111 species of phytoplankton, 50 species of zooplankton, 54 species of animals and 104 species of zoo benthic (Phan Van Mach, 2008). However, the ecosystem of the river section from Cau To to Cong Than is very poor. The maintenance and development of the plant species in the river ecosystem is very useful for improving river water quality considering the role of these species in purifying water (Vu Trung Tang, 2009). In this study, *Cyperus A.* is investigated as a potential plant to improve Nhue river water quality contaminated by organic substances and a significant amount of heavy metal.

2. Material and study methods

2.1. Experiment materials

Experimental materials were include of:
- Glass tank with size 45cm x length 50cm x height 35cm wide;

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- Cyperus A. taken from Nhue river basin;
- Water and sediment were taken from four locations Cau To, Cau Chiec, Dong Quan and Cong Than (Fig.1) a day before the experiment. A pump with capacity of 2.5 W was used for each tank to maintain the current with velocity 0.11, 0.13, 0.15 and 0.17 m/s for four study positions.

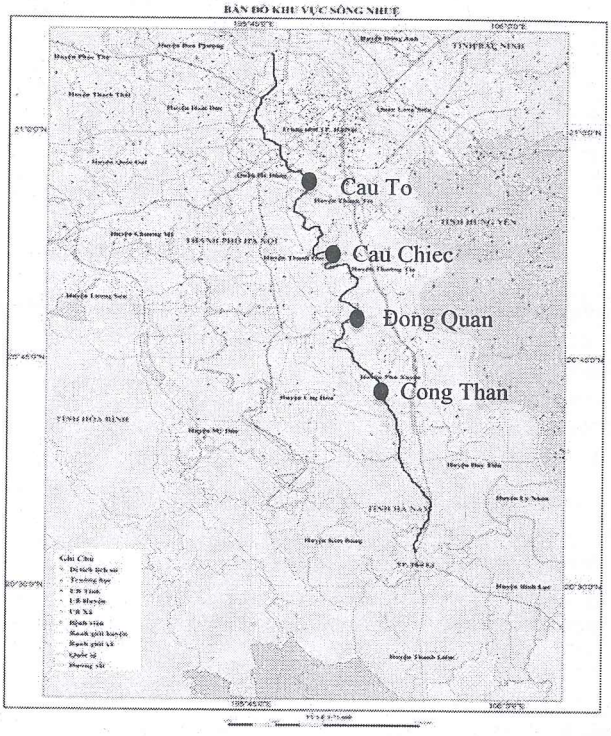

Fig 1. The sampling sites in Nhue river

2.2. Experiment set up

Water and sediment were poured into a tank such that sediment to be with 15cm height and 25cm water column. There were 4 groups of tanks, that contained same water and sediment collected from each location. Initial fresh biomass (FB) was used 456g (24gDW)/ tank equivalently to density of 2600g/m^2 plant. Samples of water, sediment, vegetation samples before the experiment was taken away for analysis in laboratory of Vietnam Academy of Science and Technology. Experiment was conducted from on 2/11/2015 (9 am) to on 1/12/2015 (9 am).

Water and sediment were half removed and replaced with new sediment and water at every three days. NH_4^+, TP, TN, Fe, Zn, Pb, Cd in the water samples, sediment samples were analyzed at different time intervals (APHA, AWWA, WEF, 1998)

2.3. Data calculation

* *Calculate pollutant absorption ability of plant*

$$HT_{HM}=P*Content_{t2} \quad (1)$$

- HTHM: Pollutant absorption ability of plant (mg/m^2/day)
- P: Productivity of plant (GDB/m^2/day)
- Contentt2: Content of pollutant at final experiment time (mg/GDB)

**Calculate translocated heavy metal possibility of plants*

Translocation factor (TF) is the ratio between heavy metal content in stem and leave to heavy metal content in roots.

$$TF= C_{stem+leaf}(\mu g/g) / C_{root}(\mu g/g) \quad (2)$$

3. Results and discussion

3.1. Nhue river water and sediment quality

Experiment results show Nhue river water quality with slightly alkaline pH in range of 7.1 ÷ 7.5, low DO (1.3 ÷ 3.9mg/l), high N- NH_4^+, P- PO_4^{3-}, high of Fe, Zn (Table 1). Compare to QCVN 08-MT:2015/BTNMT - B1 (Ministry of Natural Resources and Environment of The socialist Republic of Vietnam, 2016), Nhue river water quality does not qualify as irrigation water.

Table 1. Nhue river water quality before experiment

No.	Sites	Water quality parameters (mg/l)											
		pH	TSS	DO	NH_4^+	PO_4^{3-}	As	Cd	Cu	Pb	Hg	Fe	Zn
1	Cau To	7.7	290	1.3	7.14	3.11	0.008	0.008	0.03	0.019	0.003	2.81	1.5
2	Cau Chiec	7.4	236	1.7	6.65	1.61	0.009	0.008	0.08	0.037	0.005	1.52	0.81
3	Dong Quan	7.3	215	2.4	4.97	1.64	0.015	0.006	0.06	0.018	0.006	2.41	0.82
4	Cong Than	7.3	231	3.9	4.41	0.57	0.01	0.004	0.04	0.027	0.006	1.64	0.65
QCVN 8/2008/BTNMT - B1		5.5÷ 9	50	≥4	0.5	0.3	0.05	0.01	0.5	0.05	0.01	1.5	1.5

Heavy metals go into the environment through natural processes as well as due to anthropogenic reasons. A large portion of these metals come into aquatic ecosystems and broken down into small particles, a part precipitated down to form sediment, accumulated over time.

Heavy metal in Nhue river sediment such as lead, cadmium, zinc were high, reached the limit value of QCVN 43:2012/BTNMT (Ministry of Natural Resources and Environment of The socialist Republic of Vietnam, 2012), particularly levels of lead found 3.64 ÷ 4.78 times higher than limit values.

Table 2. Heavy metal in Nhue river sediment

No.	Sites	Sediment quality parameters (mg/kg)						
		As	Cd	Cu	Pb	Hg	Fe	Zn
1	Cau To	0.29	14.2	126.2	330.2	0.02	279.1	341.6
2	Cau Chiec	0.86	9.8	109.7	336.8	0.05	291.4	311.2
3	Dong Quan	1.02	7.1	106.3	248.2	0.05	255.8	272.8
4	Cong Than	0.9	6.2	94.8	275.2	0.04	318.5	265.5
QCVN 43:2012/BTNMT		17	5	197	91.3	0.5	-	315

Nhue River water is polluted by organic matters and a significant amount of heavy metal. *Cyperus A.* can purify effectively these pollutants or not will show in high development of biomass and high content of this pollutants inside plant tissues when grown by this water sources. Moreover, the growth of plants depends on the concentration of pollutants and absorption capacity of the plant to pollutants. Therefore, during the experiment time, plant biomass to be identified in order to define the growth as well as evaluating to absorb pollutant ability of plant.

Experiment results showed that the highest biomass increase was found in Cong Than sample pool, up 54% compared with the initial time, the lowest biomass increase noted at the Cau Chiec sample tank with biomass increased 45%. Thus the productivity of *Cyperus A.* when grown in Nhue river water and sediment are in range of 4.6 ÷ 6.0 GDB/m^2/day.

3.2. Content of nutrient and heavy metals inside tissues of Cyperus A.

3.2.1. Content of nutrient inside tissues of Cyperus A.

Cyperus A. absorps nitrogen compounds as NH_4^+, NO_3^- and phosphorus compounds to form plant biomass. In Nhue water environment, there are high concentration of NH_4^+ and PO_3^- which is the favourable condition for plant growth. There are reports published about high NH_4^+ and PO_3^- concentration also restrict the growth of plants. However, in Nhue water environment, *Cyperus A.* grew well, gave high yield which represent the ability to live well in the environment contaminated with high concentration of these pollutants.

Nitrogen and phosphorus are absorbed by plant not only for increasing biomass, but also for increasing content in plant tissue. Analysis results showed that content of nitrogen and phosphorus in *Cyperus A.* markedly increased after the experiment. Fig. 2 presents the changes of TN content inside *Cyperus A.* tissues before and after periods of experiment. Initial TN of *Cyperus A.* was 16.2 mg/g DW, after 7 days, it was in range of 16.3 ÷ 16.8, then, finally, TN was in range of 16.6 ÷ 17.1 mg/g DW, up from 0.4 ÷ 0.9 mg TN/g DW, equivalent up 2.5 ÷ 5.5% amounts in plant tissue.

Final TP in plant tissues also increased significantly compared to initial TP. Fig.3 shows the change of total average phosphorus concentration in the tissues of *Cyperus A.* before and after times experiment. The average initial TP content in tissues of *Cyperus A.* was 4,23mg/g DW, after 7 days, it was in range of 4.33 ÷ 4.38. Final

average TP content was in range of 4.42÷ 4.48 mg/g DW, up from 0.19 ÷ 0.25 mg/g DW, equivalent to 4.5 ÷ 5.9% increased.

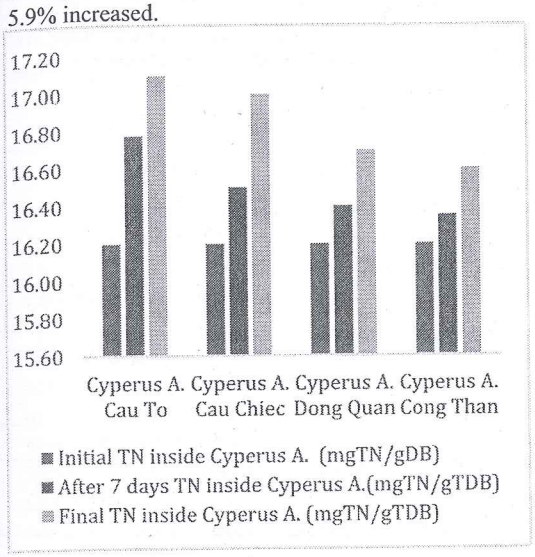

Fig. 2. TN inside Cyperus A. tissue at times of experiment

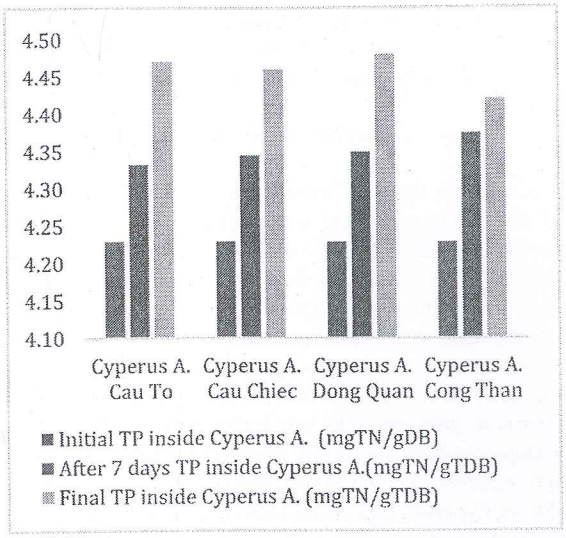

Fig. 3. TP inside Cyperus A. tissue at times of experiment

3.2.2. Content of heavy metals inside tissues of Cyperus A.

Heavy metal content has changed significantly in tissues of Cyperus A. after the experiment. Fe, Zn were detected a very small amount in initial tissues, few ppm Fe and Zn, finally, after experiment detected a large content, dozens of times higher than. The analysis results also showed that the heavy metal content was different between different parts of the plant. Table 3 presents the heavy metal absorption of *Cyperus A.* when grown in Nhue river water.

The translocated heavy metals from roots to stem and leaves of *Cyperus A.* (TF) grown in Nhue river environment were at good level with Fe (TF = 0.4÷ 0.6) and at high level with Zn (TF = 0.63÷0.83). This is so meaning for biomass treatment process, good translocating heavy metals to stem and leaf would be easy for permanently removing pollutants from the environment only by cutting these parts and taking out of the river.

Table 3. Heavy metal inside tissue of Cyperus A. at phases of experiment

Sample	Heavy metal	Heavy metal inside *Cyperus A.* tissues (ppm)									TF	QCVN 07: 2009/ BTNMT(ppm)
		Initial experiment			7 days experiment			Final experiment				
		Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root		
Cyperus A. Cau To	Fe	0.4	5.2	9.8	3.7	39.8	109.6	16	102	293	0.40	-
	Zn	0.8	4.5	8.7	16.6	45.2	89.5	39	152	290	0.66	5000
Cyperus A. Cau Chiec	Fe	0.4	5.2	9.8	6.0	65.2	182.9	15	113	280	0.46	-
	Zn	0.8	4.5	8.7	21.4	62.9	126.1	40	147	298	0.63	5000
Cyperus A. Dong Quan	Fe	0.4	5.2	9.8	5.0	55.6	154.4	14	121	318	0.42	-
	Zn	0.8	4.5	8.7	30.0	88.2	179.6	37	153	252	0.73	5000
Cyperus A. Cong Than	Fe	0.4	5.2	9.8	3.6	39.6	108.0	19	160	297	0.60	-
	Zn	0.8	4.5	8.7	36.7	100	183.4	40	125	200	0.83	5000

Compared to the study of X. Liao et al (2005), content of heavy metals in tissues of *Cyperus A.* are grown by Nhue river water were lower than the concentration of heavy metals in tissues of this experiment conducted. This is because heavy metal concentration in Nhue river water lower heavy metal concentration added to the water environment of the study. Recognising the concentration of heavy metals in the tissues of the plant is proportional to the concentration of heavy metals in river water. This has been demonstrated in studies of Kabata-Pendias et al (1984), that the heavy metal content in plant is a function of heavy metal concentration in the environment.

3.3. The effect of Cyperus A. in pollutant absorption

In process of growth, *Cyperus A.* absorbed pollutants in Nhue water to synthesize plant biomass. Experiment results showed that, in Dong quan sample tank, *Cyperus A.* absorbed pollutants best, then to Cong Than, Cau Chiec sample tanks. Ability to absorb pollutants worst of *Cyperus A.* was in Cau To sample tank.

Biomass increment and TN, TP, metals inside *Cyperus A.* proved ability of this plant to absorb TN, TP metals from water environment. In early stages (the first 7 days experiment), *Cyperus A.* have absorbed 14.5 ÷ 23.4% TN, 16 ÷ 21 % TP in water environment of Nhue river. In phase 2 experiment (last 7 days), 7.6 ÷ 12% of TN

and TP 12 ÷ 14% is absorbed from the aquatic environment. Therefore, after 14 days experiment, *Cyperus A.* absorbed 26 ÷ 33% TN and 30 ÷ 34% TP.

In the first phase experiment, *Cyperus A.* absorb 0.3 ÷ 0.8% Fe, 0.6 ÷ 1.2% Zn from water environment. In the second stage 0.6 ÷ 1.5% Fe, 0.8 ÷ 1.5% Zn in aquatic water absorbing by this plant. Thus, diffrent with nutrients N, P, heavy metal Fe, Zn *Cyperus A* was strongly absorbed in the final stage of experiment.

3.4. Variation of Nhue river water and sediment environment

During the times of experiment, water environment parameter values of *Cyperus A.* growing tanks has significantly been diffrent with control tanks. The parameter variation tend of Nhue river water in *Cyperus A.* growing tanks is suitable for the growth of aquatic organism and satisfy the threshold allowed by QCVN 08- MT : 2015 / BTNMT - B1 at final time experiment while at control tanks, water parameter variation were very slowly and far from the threshold allowed by QCVN 08- MT : 2015 / BTNMT - B1.

The change in pH when growing *Cyperus A.* was fluctuating in neutral, in range of 6.9 ÷7.3. Over time, TSS measurement results in all *Cyperus A.* growing tank fell sharply than the control tanks. This demonstrates the superiority of *Cyperus A.* than in the removal of suspended matter to clean water sources. Reduction TSS in *Cyperus A.* growing tanks was higher than control tanks about 13.8 ÷ 25%. Thus by the root system of cluster development with the ability to secrete mucus attract pollutants into the root zone environment for beneficial microorganism decomposition, absorption, metabolism of pollutants, *Cyperus A.* decreased TSS effectively. DO value of *Cyperus A.* growing tanks tends to increase rapidly over time, the value represented by the DO at the middle and end of experiment were higher than the value of the input DO. DO in the *Cyperus A.* growing tanks increased 2,6÷3,6mg/l while at control tanks increased 0,7 ÷ 1,5mg/l; For COD, in control tank, 29 ÷ 68% COD compare to 80 ÷ 83% in *Cyperus A.* growing tanks, has been cleaned off from Nhue river water environment; Total coliform value of *Cyperus A.* growing tanks varies rapidly over time and get the values satisfy QCVN 08-MT : 2015 / BTNMT - B1 at final time experiment; For P- PO_4^{3-}, in the control tanks, 49 ÷ 60% of phosphate were metabolized, deposited while in *Cyperus A.* growing tanks 88 ÷ 91% were metabolized, deposited and absorded. For ammonium, in the control tanks, 49 ÷65% were converted while in *Cyperus A.* growing tanks 89 ÷ 93% were metabolized, deposited and absorded.

Diffrent with the trend of reducing pH, organic matter, nutrients, heavy metal in water river, at *Cyperus A.* growing tanks, concentration of organic matter, nutrients, heavy metals in Nhue river sediment has increased at the end of experiment. Increase of pollutants at sediment due to deposition process, precipitation process of these pollutants. In sediment of control tanks, organic matter was increased from 2 to 4.5% while in *Cyperus A.* growing tanks, 15 ÷27% increaed. For TN, at sediment of control tanks and *Cyperus A.* growing tanks respectively, increased 1.9÷ 6% and 19 ÷ 23%. TP at sediment of control tanks increased 9 ÷17% while 24 ÷36% increased at sediment of *Cyperus A.* growing tanks.

4. Conclusion

Nhue river water was heavily polluted by organic matters and a significant concentration of heavy metals. When growing *Cyperus A.* in this environment, this plant grew well, gave high absorption to this polluted matters. During times of experiment, water environment parameter values of *Cyperus A.* growing tanks has significantly been diffrent with control tanks proving the absorption effects of this plant. The parameter variation tend of Nhue river water in *Cyperus A.* growing tanks is suitable for the growth of aquatic organism and satisfy the threshold allowed by QCVN 08- MT : 2015 / BTNMT - B1 at final time experiment while at control tanks, water parameter variation were very slowly and far from the threshold allowed by QCVN 08- MT : 2015 / BTNMT - B1.

Therefore, if interruption the source of pollution discharged into Nhue river, along with growing *Cyperus A.* on the surface of Nhue river, only for a short time, Nhue river water will be purified giving us dreamlike landscape as in some decades ago.

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