Effects of Pb Tailings Exudated Liquids Stress on the Growth, Pb Accumulation and Translocation Ability of Six Kinds of Aquatic Plants

Yao Na
College of Life Sciences, Engineering Research Center of the Chinese Ministry of Educationfor Bioreactor and Pharmaceutical Development, Jilin Agricultural University,130118

Key Words: Pb tailings exudated liquids, aquatic plants, Pb accumulation

Abstract. We take the selection of appropriate remediation plants as the purpose in the study. We select six kinds of aquatic plants with strong survivability and good ornamental performance to conduct the experiment, namely Iris pseudacorus L.,Sagittaria sagittifolia L., Eleocharis tuberosa S., Typha orientalis Pres., Phragmites australis (Cav.) Trin.ex Steud and Hydrocotyle vulgaris L.. We study the growth, Pb ions accumulation and translocation ability of six kinds of aquatic plants under Pb tailings exudated liquids(PbL). Thus, we hope that this study can provide some helps for the future in-depth study on aquatic plants remediation of the water body polluted by heavy metal.

The remediation of the water body polluted by heavy metal is quite vast and numerous, and complex. Currently traditional remediation technologies with a certain results include chemical method include using chemical method to subside the pollutants, using the extraction method to transfer the pollutants, using activated carbon and silica gel method to adsorb the pollutants and others. The principle is to first make the soil or water body transfer and then eliminate the metal ions according to the above all kinds of technologies. This kind of project has high input cost, complex operation implementation process and needs special-purpose equipment, technologies and skilled manual. The phytoremediation technology is a kind of emerging phytoremediation method of the water body polluted by heavy metal with the plants as the phytoremediation main body. Compared with the traditional physical, chemical and other engineering repair technologies and means, because the phytoremediation technology has less investment, low maintenance cost and simple operation, especially it doesn't cause secondary pollution, and it more conforms to the environmental protection requirement, its obvious economic benefits and potential social benefits gain the popularity of the related people in European and American developed countries and various countries in the world. At present, the phytoremediation technology of soil heavy metal has been mature increasingly, and the phytoremediation technology study of water body polluted by heavy metal has accelerated the speed. In the middle of the last century, with the higher and higher industrialization degree, some European and American countries became aware of the seriousness of heavy metal pollution situation, so people had to put the research work of pollution and regulation of water environment heavy metal on the agenda. At present, because of high survival rate, easy cultivation, strong adsorption and other advantages the water floating plants have gradually entered the public eye. However, because physiological environment of each contaminated waters and physiological characteristics of each plant are different, it makes the selection of appropriate remediation plants become an urgent matter of using and promoting phytoremediation technology in heavy metal pollution waters.

1. Materials and Methods

1.1 Experimental Materials

The supplied experimental plants include Iris pseudacorus L.,Sagittaria sagittifolia L., Phragmites australis (Cav.) Trin.ex Steud , Eleocharis tuberosa S., Typha orientalis Pres. and Hydrocotyle vulgaris L.

The supplied experimental solution is exudated liquids obtained from the abandoned tailings after precipitation in lead ore regions of Dexing City, Jiangxi province, namely Pb tailings exudated liquids(PbL).

1.2 Experimental Methods

1.2.1 Seedlings Cultivation and Pb Tailings Exudated Liquids Treatment

We mainly adopt Han Yulin and other people's methods to treat the six kinds of plant seedlings. After we select the uniform seedlings to cultivate them for a week so as to restore their growths in 1/4 Hoagland nutrient(HN), we plant four seedlings respectively in plastic basin with the size of 10cm×15cm to conduct Pb tailings exudated liquids treatment. We conduct two treatments by setting 1/4 Hoagland nutrient(CK) in control group, and Pb tailings exudated liquids(PbL) in treatment group. We repeat each treatment for three times. We place the six kinds of plants in the laboratory facing the sun to let them grow with 25 ℃ average temperature and 35000Lux average light. In the treatment period according to the specific conditions we supply the six kinds of plants with a certain amount of water every morning and evening. After 77 days of treatment, we take samples to measure growth, Pb concentration and other indexes.

1.2.2 Measurement of Plant Growth Index, Pb Ions Accumulation and Translocation Ability

After 77 days of treatment on the six kinds of plant seedlings, we take the seedlings out and rinse them thoroughly with water, and after we suck the water on the plant surface dry we select the same parts of plant seedlings above-ground and under-ground parts to measure each physiological index. We adopt Gu Xiaohan and other people's methods to measure the average seedling height, root length and each seedling dry weight of above-ground and under-ground parts of six kinds of plant seedlings.

The measurement for metal ions of six kinds of plants: First we use HNO3-HCIO4 wet digestion method to treat six kinds of plants, and then we use flame atomic absorption spectrophotometer to measure Pb ions content in plants.

We adopt Jiang Zhaofa and other people's methods to calculate plants tolerance index. We adopt Luo Yaping and other people's methods to calculate translocation factor.

Tolerance index(TI%)=plants root length of Pb tailings exudated liquids with different contents in treatment group/plants root length in control group×100%

Translocation Factor(TF)=the heavy metal content of plants above-ground part/the heavy metal content of plants under-ground part×100%

1.3 Data Calculation and Statistical Analysis

About calculation and analysis of experiment data, we adopt Excel 2003, WPS Office system and SPSS linear regression analysis software to conduct, and use the STST analysis software to do difference significance analysis on experimental data. When $P<0.05$, there is significant difference.

2. Results and Analysis

2.1 Effects of Pb Tailings Exudated Liquids Stress on the Growth of Seedling Height and Root Length of Six Kinds of Aquatic Plants

Under the Pb tailings exudated liquids treatment, the seedling heights of Iris pseudacorus L.,Sagittaria sagittifolia L., Phragmites australis (Cav.) Trin.ex Steud, Eleocharis tuberosa S., Typha orientalis Pres. and Hydrocotyle vulgaris L. are 74.2%, 92%, 93.9%, 96.8%, 72.7% and 94.7% of the control group. Among them, only the seedling heights of Iris pseudacorus L and Typha orientalis Pres. have reached significant level compared with the control group($P<0.05$). It shows that Pb tailings exudated liquids stress on the growth of above-ground parts of the four kinds of plants, Sagittaria sagittifolia L,Phragmites australis (Cav.) Trin.ex Steud, Eleocharis tuberosa S., and Hydrocotyle vulgaris L. Has weak inhibitory effect. The root lengths of the six kinds of plants are 88.2%, 68.6%, 94.1%, 97.4%, 57.1% and 90% of the control group respectively. Among them, the root lengths of Iris pseudacorus L.,Sagittaria sagittifolia L., and Typha orientalis Pres. have reached significant level compared with the control group($P<0.05$). Expect the seedling height of Sagittaria sagittifolia L. is slightly lower than its root length, the seedling heights of other five kinds of plants are all higher than their root lengths. Under PbL treatment the seedling heights of Iris pseudacorus L. and Phragmites australis (Cav.) Trin.ex Steud are 67% and 106.7% higher than their root lengths respectively. However, the root length of Sagittaria sagittifolia L. is only 2% higher than its seedling height. It shows that inhibitory effect of Pb tailings exudated liquids on the root lengths of most aquatic plants is larger than inhibitory effect on seedling heights.

2.2 Effects of Pb Tailings Exudated Liquids Stress on the Dry Weights of Six Kinds of Aquatic Plants

Seen from Table 1, under Pb tailings exudated liquids treatment, the above-ground parts of the five kinds of plants, Iris pseudacorus L., Eleocharis tuberosa S., Typha orientalis Pres., Phragmites australis (Cav.) Trin.ex Steud, and Hydrocotyle vulgaris L. all have reached significant level compared with the control group(P<0.05). They are 20%, 39%, 48%, 61% and 33% of the control group respectively. In six kinds of plants, only under-ground part dry weights of Iris pseudacorus L. and Eleocharis tuberosa S. have reached significant level compared with the control group(P<0.05). They are 40% and 50% of the control group respectively. Under PbL stress, above-ground part and under-ground part dry weights of Sagittaria sagittifolia L. both haven't reached significant level compared with the control group(P<0.05). It shows that Sagittaria sagittifolia L. has better tolerance to Pb tailings exudated liquids treatment.

Table 2-1 Effects of PbL on of DWs of six aquatic species

Species	Treatments			
	CK		PbL	
	Above-ground part	Under-ground part	Above-ground part	Under-ground part
Iris pseudacorus L.	0.25±0.02 a	0.10±0.01 a	0.05±0.03 b	0.04±0.02 b
Sagittaria sagittifolia L.	0.22±0.04 a	0.10±0.01 a	0.12±0.02 a	0.06±0.01 a
Eleocharis tuberosa S.	0.33±0.03 a	0.12±0.02 a	0.13±0.01 b	0.06±0.02 b
Typha orientalis Pres.	0.29±0.04 a	0.12±0.01 a	0.14±0.03 b	0.08±0.02 a
Phragmites australis (Cav.) Trin.ex Steud	0.28±0.04 a	0.14±0.04 a	0.17±0.01 b	0.08±0.03 a
Hydrocotyle vulgaris L.	0.30±0.02 a	0.10±0.01 a	0.10±0.03 b	0.08±0.01 a

Different small letters in the same column indicate the significant difference by Duncan's new multiple range test (P<0.05).

2.3 Effects of Pb Tailings Exudated Liquids Stress on Tolerance Index of of Six Kinds of Aquatic Plants

Seen in Table 2, after the Pb tailings exudated liquids treatment, the seedling heights of six kinds of aquatic plants have comparatively significant difference compared with the control group(P<0.05). Among them, the highest value among the tolerance indexes of Eleocharis tuberosa S. and Phragmites australis (Cav.) Trin.ex Steud reaches above 0.9, and the tolerance indexes of Hydrocotyle vulgaris L., Iris pseudacorus L. and Sagittaria sagittifolia L. decrease progressively, and the tolerance index(TI) of Iris pseudacorus L. has the lowest value, 0.57. Among the six kinds of plants the tolerance indexes of Iris pseudacorus L., Phragmites australis (Cav.) Trin.ex Steud, Eleocharis tuberosa S., and Hydrocotyle vulgaris L.are all larger than 0.8. It shows that the four kinds of plants have stronger tolerance under Pb Tailings Exudated Liquids stress condition, and Pb Tailings Exudated Liquids stress can promote the above-ground part growth of plants to a certain extent.

By synthesizing the analysis of the results of seedling height, root length, above-ground part and under-ground part dry weights, and tolerance index, Sagittaria sagittifolia L., Phragmites australis

(Cav.) Trin.ex Steud, and Eleocharis tuberosa S. have stronger tolerance to Pb tailings exudated liquids.

Table 2-2 Effects of PbL stress on the tolerant indexes(TI) of six aquatic species

Species	Plants	Iris pseudacorus L.	Phragmites australis (Cav.) Trin.ex Steud	Sagittaria sagittifolia L.	Eleocharis tuberosa S.	Typha orientalis Pres.	Hydrocotyle vulgaris L.
tolerance indexes	TI	0.88	0.94	0.69	0.97	0.57	0.9

2.4 Effects of Pb Tailings Exudated Liquids Stress on Pb Accumulation of Six Kinds of Aquatic Plants

Under the Pb tailings exudated liquids treatment, the above-ground part Pb contents of Iris pseudacorus L.,Sagittaria sagittifolia L., Eleocharis tuberosa S., Typha orientalis Pres., Phragmites australis (Cav.) Trin.ex Steud and Hydrocotyle vulgaris L. are all higher than the control group, and they are 15 times, 6.9 times, 25 times, 6 times, 7.4 times and 17 times of the control group respectively. Among them, Iris pseudacorus L., Phragmites australis (Cav.) Trin.ex Steud and Hydrocotyle vulgaris L. have the most significant difference compared with the control group($P<0.05$). The under-ground part Pb contents of the six kinds of plants are all higher than the control group. The under-ground part Pb contents of Iris pseudacorus L.,Sagittaria sagittifolia L., and Phragmites australis (Cav.) Trin.ex Steud are 14 times, 5 times and 10 times respectively. They have a certain difference compared with the control group. The above-ground part and under-ground part Pb contents of the three kinds of plants are 78.13μg/g and 115.63μg/g, 69.63μg/g and 77.58μg/g, and 50.71μg/g and 55.33μg/g respectively.

2.5 Effects of Pb Tailings Exudated Liquids Stress on Pb Translocation Ability of Six Kinds of Aquatic Plants

Through the translocation factors data in Table 3, it show that under PbL treatment, the above-ground part Pb contents of Iris pseudacorus L.,Sagittaria sagittifolia L., and Phragmites australis (Cav.) Trin.ex Steud are 68%, 90% and 91% of the under-ground part respectively. Among them, the translocation ability of Phragmites australis (Cav.) Trin.ex Steud is the largest. The above-ground part Pb accumulations of the six kinds of plants are all smaller than the under-ground part. The under-ground part Pb accumulation is the largest.The sequence of Pb translocation factors of six kinds of aquatic plants arranged according to size is shown as follows, Phragmites australis (Cav.) Trin.ex Steud >Sagittaria sagittifolia L. >Hydrocotyle vulgaris L.>Eleocharis tuberosa S. >Iris pseudacorus L.> Typha orientalis Pres.

Table 2-3 Effects of PbL on Pb translocation factors of six aquatic species

Species	Iris pseudacorus L.	Phragmites australis (Cav.) Trin.ex Steud	Sagittaria sagittifolia L.	Eleocharis tuberosa S.	Typha orientalis Pres.	Hydrocotyle vulgaris L.
CK	0.43	0.67	0.83	0.80	0.50	0.31
PbL	0.68	0.91	0.90	0.76	0.64	0.84

3. Discussion

Pb with low concentration can promote the growth and development of plants, but Pb element with excessive amounts can lead to plants poisoning and do harm to the plants in various aspects. Studies have found that the net elongate ratio of Iris pseudacorus L. leaves and root system under the Pb stress with low concentration have the significant growth, and it can be suppressed under high concentration. In this experiment, Pb liquids with high concentration don’t have too many inhibitory effects on the above-ground part and under-ground part growths of Eleocharis tuberosa S..

It shows that Eleocharis tuberosa S. has stronger Pb tolerant ability. However, under the Pb stress with high concentration, the above-ground part and under-ground part of other five kinds of plants have been affected in different degrees. Among them, the above-ground part value of Iris pseudacorus L. under the Pb liquids treatment with high concentration is 74% of control group, and the under-ground part value is 88% of control group. The tolerance indexes showed by the plants in adverse situation of heavy metal stress through their own growth characteristics can indirectly show the plants' tolerance degree to heavy metals. The larger the tolerance index is, it shows the stronger the tolerance degree of this mental stress is. From Table 1 it reflects that the tolerance index of Eleocharis tuberosa S. Is the highest. It shows that its under-ground part has a good adaptability on Pb liquids with high concentration. However, the tolerance indexes of Typha orientalis Pres. and Sagittaria sagittifolia L. are both lower. It is concluded that the underground parts of Typha orientalis Pres. and Sagittaria sagittifolia L. have poorer Pb tolerance ability.

Generally speaking, Pb liquids treatment with high concentration don't do great harm to six kinds of aquatic plants. Among six kinds of plants Typha orientalis Pres. and Hydrocotyle vulgaris L. have weak growing conditions at the beginning of the treatment. After the self adjustment from 15 to 17 days, they gradually adapt to the high Pb treatment environment. Comparatively speaking, Eleocharis tuberosa S., Iris pseudacorus L., Sagittaria sagittifolia L. and Phragmites australis (Cav.) Trin.ex Steud have stronger Pb tolerance ability. Pb liquids treatment on some degree contrary helps the growth of the four kinds of plants. Among them, the Pb accumulation amount of Iris pseudacorus L. and Eleocharis tuberosa S. under-ground part is higher than Sagittaria sagittifolia L. and Phragmites australis (Cav.) Trin.ex Steud, and at the same time Sagittaria sagittifolia L. and Phragmites australis (Cav.) Trin.ex Steud show the high mobility of Pb metal ions. It shows that Iris pseudacorus L. and Sagittaria sagittifolia L. have stronger remediation ability for water body polluted by Pb tailings in the experiment.

References

[1]Akcil A, Erust C, Ozdemiroglu S, Fonti V, Beolchini F. *A Review of Approaches and Techniques Used in Aquatic Contaminated Sediments: Metal Removal and Stabilization by Chemical and Biotechnological Processes.* Journal of Cleaner Production, 2015, 86:24~36.

[2]Mukwaturi M, Lin C. *Mobilization of Heavy Metals from Urban Contaminated Soils under Water Inundation Conditions.* Journal of Hazardous Materials, 2015, 285: 445~452.

[3]Wu Zhenghua. *Application of Soil Heavy Metal Pollution Phytoremediation and Gene Technology* [J]. Agriculture Environmental Protection, 2002，21(1)：84~86.

[4]Huang Yongjie, Liu Dengyi, Wang Youbao, etc. *Comparative Study on Accumulation Ability of Eight Kinds of Aquatic Plants on Heavy Metal* [J]. Chinese Journal of Ecology, 2006，25(5)：541~545. .