PLANTS SELECTION FOR DOMESTIC SEWAGE TREATMENT IN JILIN CITY

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ABSTRACT

This experiment studied the removal efficiency of domestic sewage by testing 19 species of wetland plants along the Songhua River in Jilin City. It is shown that plants can purify domestic sewage, and the ability of removal efficiency is varied on different species. *Rumex patientia* var.callosus is the best in removal efficiency of TN(29.14%);*Coleus blumei* Benth. could effectively reduce output of TP and COD,the best removal efficiencies for TP is 58.04%, COD is 95.18%; *Oenanthe javanica*(Blume) DC. has better efficiency to increase DO in sewage, and the maximum increase is 262.22%;*Rumex.patientia* var.callosus,*Alisma orientale*(Sam.)Juz.,*Oenanthe javanica*(Blume) DC.,*Erigeron annuus* (L.) Pers. may be used as plants for the construction of sewage treatment landscape, because these plants have better comprehensive capacity for domestic sewage treatment.

Water pollution has become a general and worldwide problem today. The application of wetland plants for waste water treatment features low cost,easiness to manage, high efficiency and etc.(Han Xiaoyuan etc.,2005;Li linfeng etc.,2006;Zhang Honggang,Hong Jianming,2006).Wetland plants can not only absorb nitrogen and phosphorus directly but also remove the heavy metals and organics in the waste water. (Xu Weiwei etc.,2005;Cheng Wei etc.,2005;C.C.Tanner,2001;Tang Shirong,2006;SAMAKEMoussa,2003;L.K.Mitchell,A.D. Karathanasis,1995).According to current research reports,*Phragmitas communis* Trin, *Juncus effuses* Linn, Rush, and *Iris japonica* Thunb, Buttery Swordflag can efficiently remove nitrogen and phosphorus from the sewage (Deng Futang etc.,2005;Yuan Donghai etc.,2004;A. Fey,G. Benckiser,J.C.G. Ottow,1999).The constructed wetlands consisting of varied plants,such as *Phragmitas communis* Trin,*Canna indica* Linn. or *Acorus gramineus* Soland,Grassleaved Sweetflag,are effective in eliminating chemical oxygen demand(“COD”) in the waste water(Zhao Jiangang etc.,2006;Zhong Yushu etc.,2006;Yuan Donghai etc.,2004).Therefore wetlands can be used to reduce water pollution(Weng Meiya etc.,2005;Liu Zilian etc.,2005;Robert M. Seams,1995).So far most current studies have been developed in the South China with few in the Northeast area of China.

19 kinds of wetland plants growing along the Songhua River is selected in Jinlin City. We analyze and decide which plants are suitable for plant landscape application due to their better urban sewage treatment functions.

KEY WORDS
Domestic sewage, purification, plant, selection

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1 MATERIALS AND METHODS

1.1Materials

1.1.1Water sample

Sample water was collected from the domestic sewage outfall under the Linjiangmen Bridge of Songhua River in Jilin City at 6:00 A.M. Afterwards we poured the various kinds of plants with such sample water (or “Input Water”)to compare and analyze their experimental indicators simultaneously.

1.1.2Plants

19 species of plants healthily growing nearby the sewage outlets along Songhua River is selected as the study objects (Table 1), based on their adaptability to environment, strength to resist pollution substances and the capability of pest resistance.

Tab.1 Plants Analyzed in the Experiments

No.	Chinese N	Latin Name
1	泽泻	*Alisma orientale* (Sam.)Juz.
2	和尚菜	*Adenocaulon himalaicum* Maxim.
3	灰绿藜	*Chenopodium glaucum* L.
4	洋铁酸模	*Rumex patientia* var.callosus F.Schmidt
5	桃叶蓼	*Polygonum persicaria* L.
6	黑心菊	*Rudbeckia hybrida*
7	戟叶蓼	*Polygonum thunbergii* Sieb.et Zucc.
8	马蔺	*Iris lactea* var.*chinensis* Thunb
9	紫萼	*Hosta ventricosa* Stearn
10	彩叶草	*Coleus blumei* Benth.
11	艾蒿	*Artemisia argyi* Levl.et Vant.
12	白三叶	*Txifolium repens* L.
13	山莴苣	*Lactuca indica* L.
14	美汉草	*Meehania urticifolia* (Miq.)Makino
15	毛茛	*Ranunculus japonicus* Thunb.
16	连钱草	*Glechoma hederacea* L.var.longituba Nakai.
17	一年蓬	*Erigeron annuus* (L.) Pers.
18	水芹	*Oenanthe javanica*(Blume) DC.
19	鸭跖草	*Commelina communis* L.

1.2 Analysis Methods

1.2.1 Devices

Flowerpots are used to contain and grow the plants, each of which has a top diameter of 37 centimeters(“cm”), a bottom diameter of 25 cm, a height of 45cm and the 22L volume. We placed a 10 cm-thick layer of cobblestones each measuring 3-8 cm in diameter as water filter, topped with a piece of plastic window screening to prevent the sands from filling the spaces among the cobblestones. On top of the plastic window screening, there’s a layer of river sand and soil with a 25cm thickness to grow the plants(“Growing Base”). We inserted a plastic pipe with a 0.5 cm diameter into the water filter so as to output the water samples (“Output Water”) for analyzing.

1.2.2 Analyzing Procedures.

The plants are planted on the Growing Base in the earlier spring. Each kinds of plants have three groups of repeated experimental data compared with three groups of original data(Growing Base Without Plant).The objects are poured the Input Water once in 10 days. After staying in the flowerpots for 10 days, the Output Water is siphoned and immediately analyze the total nitrogen (TN), total phosphorus (TP), chemical oxygen demand (COD), dissolved oxygen (DO) contained by the Output Water in the lab.

1.2.3 Analysis Method

According to the Analysis Methods for Water and Waste Water published by State Administration of Environmental Protection, chemical analysis was carried out following the methods:

determination of TN: Alkaline potassium persulfate digestion-UV spectrophotometry method;

determination of TP: Ammonium molybdate spectrophotometric method;

determination of COD: Potassium dichromate method;

determination of DO: Iodimetry.

2 RESULTS AND ANALYSIS

The water quality was measured on July 26, August 6, August 15, and August 26 during the experiment period. Removing rates (%) of TN, TP, COD and increasing rate of DO in the water were used for the study. Equation for removing rates of TN, TP, and COD were:

Removing rate = (control concentration – measured concentration)/influent water sample concentration × 100%

Equation for increasing rate of DO:

Increasing rate = (measured concentration – control concentration)/influent water sample concentration × 100%

2.1 Results produced by different plants for removing TN in domestic sewage

Table 2 shows the TN removing rates in different periods during the experiment. The rates are calculated according to TN concentration before and after the treatment by plants.

Tab.2 TN Removing Results of Different Plants

No.	Plants	Removal (%)			
		July 26	Aug.6	Aug.15	Aug.26
1	*Alisma orientale* (Sam.)Juz.	28.5639	2.6001	1.4230	0.4184
2	*Adenocaulon himalaicum* Maxim.	1.8526	4.4303	1.3063	1.3689
3	*Chenopodium glaucum* L.	0.4837	0.3761	1.3489	1.4176
4	*Rumex patientia* var.callosus F.Schmidt	29.1353	17.9879	0.7561	1.6357
5	*Polygonum persicaria* L.	27.2340	19.8897	1.0688	2.4978
6	*Rudbeckia hybrida*	18.1210	3.2120	12.4213	1.1343
7	*Polygonum thunbergii* Sieb.et Zucc.	24.2269	8.1949	0.8178	6.3522
8	*Iris lactea* var.*chinensis* Thunb	25.5212	21.0061	1.4332	3.8069
9	*Hosta ventricosa* Stearn	23.6735	10.6034	1.2056	2.7811
10	*Coleus blumei* Benth.	19.0982	9.6979	0.8212	5.4269
11	*Artemisia argyi* Levl.et Vant.	22.5843	16.1651	1.1470	1.5483
12	*Txifolium repens* L.	2.7252	10.2567	1.2664	2.9374
13	*Lactuca indica* L.	21.0714	4.7546	0.8805	3.4309
14	*Meehania urticifolia* (Miq.)Makino	25.8014	11.6119	1.3482	2.8499
15	*Ranunculus japonicus* Thunb.	25.2410	1.8009	0.6727	1.0583
16	*Glechoma hederacea* L.var.longituba Nakai.	25.6746	10.7548	1.6004	0.5741

17	*Erigeron annuus* (L.) Pers.	23.0211	12.3546	11.1413	2.5215
18	*Oenanthe javanica*(Blume) DC.	28.3632	14.8089	0.5746	1.0594
19	*Commelina communis* L.	28.2097	12.8398	0.6734	1.8309

These rates show that most of the plants are at the highest performance level for removing TN around July 26. The performance follows a downward trend afterwards and picks up slightly on August 26. In particular, *Rumex patientia* var.callosus F.Schmidt is most effective with removing rate up to 29.13%. Those less effective plants include *Adenocaulon himalaicum* Maxim., *Txifolium repens* L., and *Chenopodium glaucum* L. with removing rate less than 10%.

Multiple comparison of TN removing rate of different plants in their most effective period shows that *Rumex patientia* var.callosus F.Schmidt, *Alisma orientale* (Sam.)Juz., *Oenanthe javanica*(Blume) DC., and *Commelina communis* L. are more effective, *Polygonum persicaria* L., *Lactuca indica* L., *Ranunculus japonicus* Thunb., *Polygonum thunbergii* Sieb.et Zucc., and *Meehania urticifolia* (Miq.)Makino are moderate, while others are less effective. Figure 1 shows the curves of purifying process of those plants with higher performance.

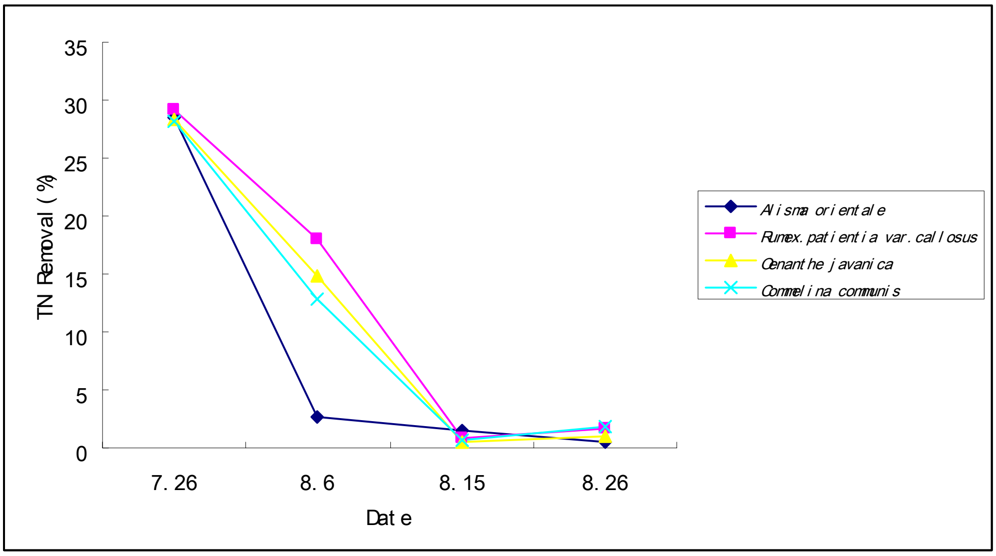

Fig. 1 TN Removing Results of Plants with Higher Performance

2.2 Results produced by different plants for removing TP in domestic sewage

Table 3 shows the TP removing rates in different periods by different plants.

Tab.3 TP Removing Results of Different Plants

No.	Plants	Removal（%）			
		July 26	**Aug.6**	**Aug.15**	**Aug.26**
1	*Alisma orientale* (Sam.)Juz.	40.3134	1.9822	43.7959	3.7326
2	*Adenocaulon himalaicum* Maxim.	42.4933	21.8052	15.4448	5.4291
3	*Chenopodium glaucum* L.	13.3381	0.6738	9.2284	1.4945
4	*Rumex patientia* var.callosus F.Schmidt	43.3711	3.1064	38.5123	5.5836
5	*Polygonum persicaria* L.	44.6646	3.3443	8.2651	4.2169
6	*Rudbeckia hybrida*	43.1836	19.5471	12.6756	2.1029
7	*Polygonum thunbergii* Sieb.et Zucc.	41.8821	11.4086	45.0056	3.8312
8	*Iris lactea* var.*chinensis* Thunb	39.2991	3.6087	26.2344	2.3687
9	*Hosta ventricosa* Stearn	33.7963	3.7965	10.4939	4.9982
10	*Coleus blumei* Benth.	45.0132	25.8707	58.0432	3.5974
11	*Artemisia argyi* Levl.et Vant.	11.2880	3.4477	8.9707	3.3195
12	*Txifolium repens* L.	0.6357	2.7328	4.5074	3.3303
13	*Lactuca indica* L.	5.7970	6.3640	2.4226	4.8201
14	*Meehania urticifolia* (Miq.)Makino	16.6732	3.4434	2.4202	2.7716
15	*Ranunculus japonicus* Thunb.	18.8343	4.7228	9.5769	1.9540
16	*Glechoma hederacea* L.var.longituba Nakai.	14.2385	3.0912	1.0901	3.2373
17	*Erigeron annuus* (L.) Pers.	44.7550	16.4736	0.5125	3.2561
18	*Oenanthe javanica*(Blume) DC.	14.6099	3.5058	13.7460	10.5836
19	*Commelina communis* L.	28.5625	8.7747	29.4353	6.8614

Most of the plants are at higher performance level for removing TP around July 26. The highest removing rate of *Coleus blumei* Benth. is 58.04%. The rate on August 6 decreases while the rate on August 16 increases before the decrease for the second time.

Txifolium repens L., *Lactuca indica* L., and *Glechoma hederacea* L.var.longituba Nakai. are always at lower performance for removing TP.

Multiple comparison shows that *Coleus blumei* Benth., *Polygonum thunbergii* Sieb.et Zucc., *Erigeron annuus* (L.) Pers., *Polygonum persicaria* L., *Alisma orientale* (Sam.)Juz., *Rudbeckia hybrida*, *Adenocaulon himalaicum* Maxim., *Iris lactea* var.*chinensis* Thunb, and *Rumex patientia* var.callosus F.Schmidt are more effective, *Hosta ventricosa* Stearn, *Commelina communis* L., *Ranunculus japonicus* Thunb., and *Artemisia argyi* Levl.et Vant. are moderate, while *Oenanthe javanica*(Blume) DC., *Meehania urticifolia* (Miq.)Makino, *Chenopodium glaucum* L., *Glechoma hederacea* L.var.longituba Nakai., *Lactuca indica* L., and *Txifolium repens* L. are less effective. Figure 2 shows the purifying process of those plants with higher performance.

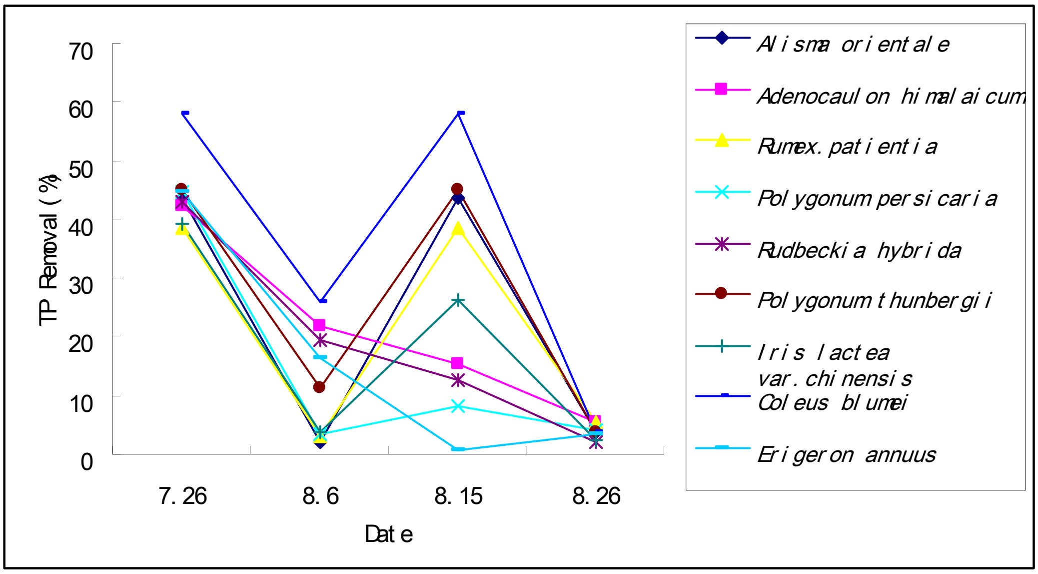

Fig .2 TP Removing Results of Plants with Higher Performance

2.3 Results produced by different plants for removing COD in domestic sewage

Table 4 shows the COD removing rates by different plants.

Tab.4 COD Removing Results of Different Plants

No.	**Plants**	**Removal（%）**			
		July 26	**Aug.6**	**Aug.15**	**Aug.26**
1	*Alisma orientale*(Sam.)Juz.	43.2031	71.2935	43.7959	3.7326
2	*Adenocaulon himalaicum* Maxim.	44.1445	91.1165	2.0039	5.4292
3	*Chenopodium glaucum* L.	14.7141	14.7140	9.2284	1.4945
4	*Rumex.patientia* var.callosus F.Schmidt	46.7437	72.4176	11.6306	5.5836
5	*Polygonum persicaria* L.	46.0406	72.6556	8.2651	4.2169
6	*Rudbeckia hybrida*	46.5823	88.8583	12.6756	2.5103
7	*Polygonum thunbergii* Sieb.et Zucc.	44.0837	80.7198	45.0056	3.8312
8	*Iris lactea* var.*chinensis* Thunb	45.3534	72.9199	18.1698	2.3686
9	*Hosta ventricosa* Stearn	45.6298	73.1077	10.4939	4.9982
10	*Coleus blumei* Benth.	46.3891	95.1819	58.0432	3.5974
11	*Artemisia argyi* Levl.et Vant.	14.0399	14.0399	8.9706	3.3194
12	*Txifolium repens* L.	0.6357	4.5074	4.5074	3.3303
13	*Lactuca indica* L.	5.7970	17.0379	2.4226	4.8201
14	*Meehania urticifolia* (Miq.)Makino	16.6731	16.6731	2.4202	2.7716
15	*Ranunculus japonicus* Thunb.	18.8343	29.0136	9.5769	1.9540
16	*Glechoma hederacea* L.var.longituba Nakai.	22.4944	22.4944	1.0900	3.2373
17	*Erigeron annuus* (L.) Pers.	46.1310	71.8948	0.5124	3.2560
18	*Oenanthe javanica*(Blume) DC.	17.3618	17.3618	13.7460	10.5836
19	*Commelina communis* L.	31.5897	78.0860	1.8681	6.8614

In the experiment period, COD removing rate indicates an upward trend followed by a downward trend. *Rumex.patientia* var.callosus F.Schmidt has the highest COD removing rate of up to 95.18% while *Txifolium repens* L. has the least rate of less than 5%.

Comparison by least significant ranges shows that *Erigeron annuus* (L.) Pers., *Rumex patientia* var.callosus F.Schmidt, *Rudbeckia hybrida*, *Hosta ventricosa* Stearn, *Polygonum persicaria* L., and *Coleus blumei* Benth. are more effective, *Oenanthe javanica*(Blume) DC., *Ranunculus japonicus* Thunb., *Lactuca indica* L., *Iris lactea* var.*chinensis* Thunb, *Polygonum thunbergii* Sieb.et Zucc., *Glechoma hederacea* L.var.longituba Nakai., *Adenocaulon himalaicum* Maxim., and *Alisma orientale* (Sam.)Juz. are moderate, while *Commelina communis* L., *Txifolium repens* L., *Chenopodium glaucum* L., *Meehania urticifolia* (Miq.)Makino, and *Artemisia argyi* Levl.et Vant. are less effective. Figure 3 shows the curve of purifying process of those plants with higher performance.

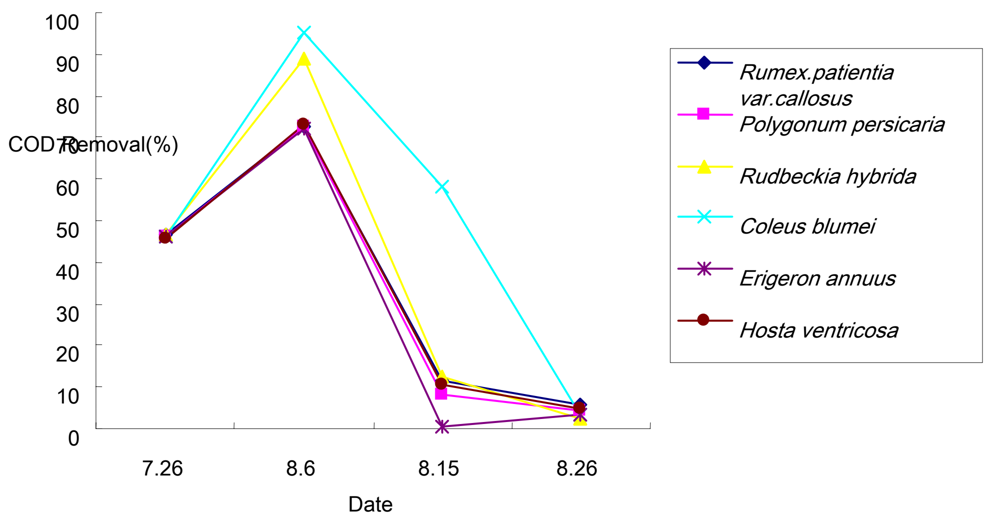

Fig.3 COD Removing Results of Plants with Higher Performance

2.4 Results produced by different plants for removing DO in domestic sewage

DO increasing results of different plants are shown in Table 5.

Tab.5 DO Increasing Results of Different Plants

No.	Plants	Increase（%）			
		July 26	Aug.6	Aug.15	Aug.26
1	*Alisma orientale*(Sam.)Juz.	52.3809	18.9393	60	6.6326
2	*Adenocaulon himalaicum* Maxim.	40.4761	46.2121	108.8889	10.3741
3	*Chenopodium glaucum* L.	7.1428	44.6969	44.6969	10.5102
4	*Rumex.patientia* var.callosus F.Schmidt	107.1428	108.3333	108.3333	24.5578
5	*Polygonum persicaria* L.	73.8095	61.3636	135.5556	19.5238
6	*Rudbeckia hybrida*	21.4285	29.5454	106.6667	11.6667
7	*Polygonum thunbergii* Sieb.et Zucc.	92.8571	15.9091	95.5556	11.7346
8	*Iris lactea* var.*chinensis* Thunb	114.2857	97.7273	114.2857	15.1361
9	*Hosta ventricosa* Stearn	95.2381	67.4242	95.2381	15.7823
10	*Coleus blumei* Benth.	161.9047	131.0606	247.7778	10.1361
11	*Artemisia argyi* Levl.et Vant.	52.3809	43.1818	68.8889	15.0340
12	*Txifolium repens* L.	111.9047	99.2424	111.9047	22.7891
13	*Lactuca indica* L.	14.2857	79.5454	57.7778	20.2721
14	*Meehania urticifolia* (Miq.)Makino	83.3333	115.9091	131.1111	16.9728
15	*Ranunculus japonicus* Thunb.	128.5714	81.0606	128.5714	14.3877
16	*Glechoma hederacea* L.var.longituba Nakai.	121.4285	56.8181	121.4285	10.8503
17	*Erigeron annuus* (L.) Pers.	154.7619	90.1515	154.7619	11.4626
18	*Oenanthe javanica*(Blume) DC.	21.4285	40.1515	262.2222	15.4761
19	*Commelina communis* L.	90.4761	65.9091	153.3333	3.7415

During the initial period of the experiment, DO Increasing rates of most plants decrease before a pick up. The lowest point is on August 26. *Oenanthe javanica*(Blume) DC. has the highest rate of increasing DO of up to 262.22% while *Chenopodium glaucum* L. is less effective, with a rate always less than 50%.

Multiple comparison shows that *Oenanthe javanica*(Blume) DC., *Coleus blumei* Benth., *Erigeron annuus* (L.) Pers., and *Commelina communis* L. are more effective, *Polygonum persicaria* L., *Meehania urticifolia* (Miq.)Makino, and *Ranunculus japonicus* Thunb. are moderate, while *Glechoma hederacea* L.var.longituba Nakai., *Iris lactea* var.*chinensis* Thunb, *Txifolium repens* L., *Adenocaulon himalaicum* Maxim., *Rumex patientia* var.callosus F.Schmidt, *Rudbeckia hybrida*, *Polygonum thunbergii* Sieb.et Zucc., *Hosta ventricosa* Stearn, *Artemisia argyi* Levl.et Vant., *Alisma orientale* (Sam.)Juz., and *Lactuca indica* L. are less effective. Figure 4 shows the curve of purifying process of those plants with higher performance.

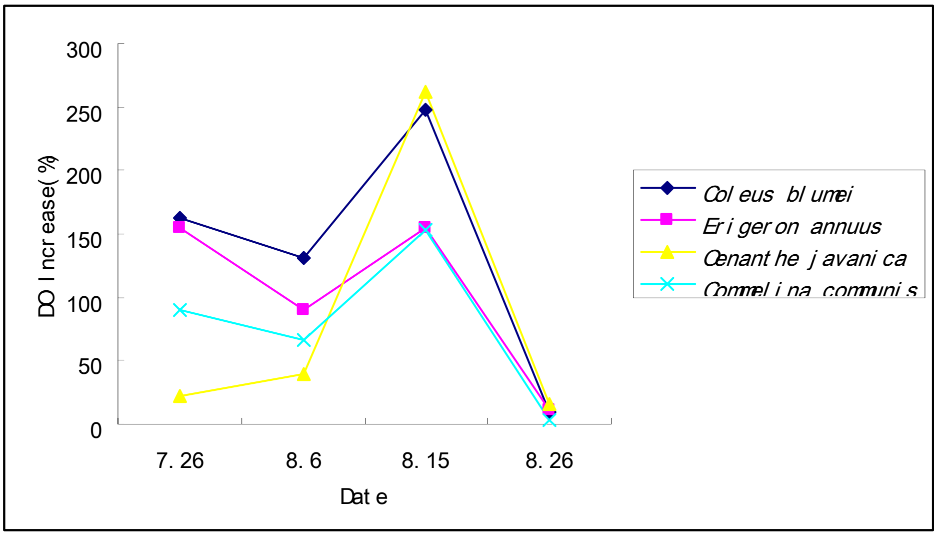

Fig.4 DO Increasing Results of Plants with Higher Performance

2.5 Comparison of comprehensive results of different plants

Weight and comprehensive scores (A) of the four indicators are determined according to the assessment method proposed by experts (Wang Yi, 2005) in their study on water purification system for wetland.

A=FTP×ωTP+ FTN×ωTN+ FCOD×ωCOD+ FDO×ωDO

ωTP= PTP/P; ωTN= PTN/P; ωCOD= PCOD/P; ωDO= PDO/P;

P=PTP+PTN+PCOD+PDO

PTP=TPi/TPo; PTN=TNi/TNo; PCOD=CODi/CODo; P (DO saturated - DOi)/ (DO $_{saturated}$ - DOo);

ωTP, ωTN, ωCOD, ωDO - weight of TP, TN, COD, DO;

TPi, TPo - measured value and benchmark of TP;

TNi, TNo - measured value and benchmark of TN;

CODi, CODo - measured value and benchmark of CO;

$DO_{saturated}$, DOi, DOo - Saturated dissolved oxygen concentration under water temperature of measurement as well as the measured value and benchmark of DO;

The benchmarks are provided in Environmental Quality Standard of Surface Water (GB3838-2002) as water quality ⍰ (TNo≤1.0mg/L, TPo≤0.2mg/L, CODo≤20mg/L, DOo≥5mg/L).

Removing rate (%) is scored according to the following rules in Table 6 by using the experimental results.

Tab.6 score criterion (F)

F	**5**	**4**	**3**	**2**	**1**
TN	Removal>27	25< Removal <27	20< Removal <27	10< Removal <20	Removal <10
TP	Removal >40	30< Removal <40	20< Removal <30	10< Removal <20	Removal <10
COD	Removal >50	40< Removal <50	30< Removal <40	20< Removal <30	10< Removal 20
DO	Increase>200	150< Increase <200	125< Increase <150	100< Increase <125	Increase <100

Table 7 shows the comprehensive scores calculated according to the above equations.

Tab.7 The sort order of total score

No.	Plants	Analysis of indicators				score
		TN	TP	COD	DO	
1	*Rumex patientia* var.callosus F.Schmidt	1.3579	0.5235	3.6126	0.1336	5.6276
2	*Alisma orientale* (Sam.)Juz.	2.2103	1.4457	1.7459	0.1134	5.5153
3	*Oenanthe javanica*(Blume) DC.	1.9338	0.1105	1.5338	1.8914	5.4695
4	*Erigeron annuus* (L.) Pers.	1.3129	0.2316	3.2968	0.4333	5.2746
5	*Polygonum persicaria* L.	1.0595	0.1668	3.2654	0.2609	4.7526
6	*Coleus blumei* Benth.	0.9615	1.6879	0.3545	1.7073	4.7112
7	*Rudbeckia hybrida*	0.7574	0.6438	2.3762	0.4202	4.1976
8	*Polygonum thunbergii* Sieb.et Zucc.	1.5314	1.3839	0.8406	0.1524	3.9083
9	*Iris lactea* var.*chinensis* Thunb	1.4452	0.9399	1.0325	0.0972	3.5148
10	*Ranunculus japonicus* Thunb.	1.6649	0.0929	1.3692	0.1748	3.3018
11	*Commelina communis* L.	1.5929	0.2937	0.6796	0.6943	3.2605
12	*Lactuca indica* L.	1.6087	0.0564	1.2781	0.1239	3.0671
13	*Meehania urticifolia* (Miq.)Makino	1.6903	0.0513	0.5703	0.6526	2.9645
14	*Glechoma hederacea* L.var.longituba Nakai.	0.9984	0.0314	1.6347	0.0711	2.7356
15	*Hosta ventricosa* Stearn	1.0177	0.5657	0.5695	0.0658	2.2187
16	*Adenocaulon himalaicum* Maxim.	0.0578	0.7268	0.4582	0.421	1.6638
17	*Artemisia argyi* Levl.et Vant.	0.8339	0.1594	0.5226	0.1408	1.6567
18	*Txifolium repens* L.	0.2087	0.0619	0.7145	0.1327	1.1178
19	*Chenopodium glaucum* L.	0.0119	0.0819	0.7239	0.0469	0.8646

Performance of different plants is ranked as *Rumex patientia* var.callosus F.Schmidt > *Alisma orientale* (Sam.)Juz.> *Oenanthe javanica*(Blume) DC. > *Erigeron annuus* (L.) Pers. > *Polygonum persicaria* L. > *Coleus blumei* Benth.> *Rudbeckia hybrida* > *Polygonum thunbergii* Sieb.et Zucc.> *Iris lactea* var.*chinensis* Thunb > *Ranunculus japonicus* Thunb.> *Commelina communis* L.> *Lactuca indica* L.> *Meehania urticifolia* (Miq.)Makino > *Glechoma hederacea* L.var.longituba > *Hosta ventricosa* Stearn > *Adenocaulon himalaicum* Maxim.> *Artemisia argyi* Levl.et Vant.> *Txifolium repens* L. > *Chenopodium glaucum* L.

3 CONCLUSION

3.1 Different purifying plants for treating domestic sewage have different performance levels.

3.2 Among the subjects, those scored more than 5 points include *Rumex patientia* var.callosus F.Schmidt, *Alisma orientale* (Sam.)Juz., *Oenanthe javanica*(Blume) DC. and *Erigeron annuus* (L.) Pers.; *Polygonum persicaria* L., *Coleus blumei* Benth., and *Rudbeckia hybrida* are between 4-5 points; *Polygonum thunbergii* Sieb.et Zucc., *Iris lactea* var.*chinensis* Thunb, *Ranunculus japonicus* Thunb., *Commelina communis* L., and *Lactuca indica* L. are 3 – 4 points; *Meehania urticifolia* (Miq.)Makino, *Glechoma hederacea* L.var.longituba Nakai., and *Hosta ventricosa* Stearn are 2 – 3 points, *Adenocaulon himalaicum* Maxim., *Artemisia argyi* Levl.et Vant.and *Txifolium repens* L. are 1 – 2 points, and *Chenopodium glaucum* L. is less than 1 point.

4 DISCUSSION

4.1 In construction landscape for water purification, *Rumex patientia* var.callosus F.Schmidt, *Alisma orientale* (Sam.)Juz., *Oenanthe javanica*(Blume) DC., and *Commelina communis* L. may be used in sewage with higher concentration of nitrogen; *Coleus blumei* Benth., *Polygonum thunbergii* Sieb.et Zucc., *Erigeron annuus* (L.) Pers., *Polygonum persicaria* L., *Alisma orientale* (Sam.)Juz., *Rudbeckia hybrida*, *Adenocaulon himalaicum* Maxim., *Iris lactea* var.*chinensis* Thunb, and *Rumex patientia* var.callosus F.Schmidt may be used in sewage with higher concentration of phosphorous; and *Erigeron annuus* (L.) Pers., *Rumex patientia* var.callosus F.Schmidt, *Rudbeckia hybrida*, *Hosta ventricosa* Stearn, *Polygonum persicaria* L., and *Coleus blumei* Benth. may be used in sewage with higher concentration of organic matters. Domestic sewage may be treated by combining plants with higher scores.

4.2 In the experiment, *Rudbeckia hybrida* demonstrates rather unique properties in removing TN and TP. TN removing performance had a pick up substantially during the experiment. TP removing performance is relatively satisfactory with a slowly downward trend. *Adenocaulon himalaicum* Maxim. and *Erigeron annuus* (L.) Pers. also showes a slightly downward trend in removing of TP. Because demand of nitrogen and phosphorous in vegetative and reproductive growth is not the same, longer blooming period of *Rudbeckia hybrida* and continuous flowering of *Adenocaulon himalaicum* Maxim. and *Erigeron annuus* (L.) Pers.may be related to the performance of the plants.

In order to optimize the performance of multi-objective landscape for water purification, the plants shall be selected based on their TN and TP removing performances, types and ingredients of pollutants removed by plants in vegetative and reproductive growth, as well as the length of phonological periods of related plants.

4.3 COD removing rate is at its highest level on July 26 while DO increasing performance is decreasing. This is because most of organic matters in the sewage are removed through decomposition by microorganism on the plants and surface of substrate. DO consumption of microorganism is at the highest level when COD removing performance is the best. Because decreasing concentration of organic matters also reduces DO consumption, DO concentration picks up gradually when restoring rate of DO is higher than the rate of consumption (Yi Jun etc. 2007; Zhao Jian etc. 2007). It follows that the COD removing and DO increasing process involves not only the plants, but also microorganism and substrate. In the construction of purifying landscape, the plants shall be cultivated for a period to stabilize the performance of the plants, microorganism, and substrate for optimizing the results of organic matters removal.

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