

Sewage Purification Effects of Several Ornamental Shrubs

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Keywords: shrubs; TP; TN; COD; purification rate.

Abstract: Using the simulated planting method, this paper compares the sewage purification effect of 7 kinds of ornamental shrubs on TP, TN and COD. The results show that, all shrubs have obvious purification effects on TP, TN and COD in sewage. The TP purification abilities of shrubs go as following: *Spiraea japonica* Gold Mound. > *Amorpha fruticosa* Linn. > *Swida alba* Opiz. > *Ligustrum obtusifolium* Sieb. > *Lespedeza bicolor* Turcz. > *Syringa oblata* Lindl. > *Forsythia mandshurica* Uyeki.. TN purification abilities of shrubs go as following: *Amorpha fruticosa* Linn. > *Spiraea japonica* Gold Mound. > *Lespedeza bicolor* Turcz. > *Ligustrum obtusifolium* Sieb. > *Swida alba* Opiz. > *Forsythia mandshurica* Uyeki. > *Syringa oblata* Lindl. COD purification abilities of shrubs go as following: *Spiraea japonica* Gold Mound. > *Swida alba* Opiz. > *Syringa oblata* Lindl. > *Amorpha fruticosa* Linn. > *Lespedeza bicolor* Turcz. > *Ligustrum obtusifolium* Sieb. > *Forsythia mandshurica* Uyeki. The purification rates show a declining trend then keep constant with time passing by.

1. Introduction

To adopt plants in ecological restoration means to give full play to plants' ecological benefits, and create conditions for the harmonious existence of human beings and water body by utilizing plants' functions of soil and water conservation, erosion prevention and control, water purification, filtering and buffering, climate regulation, environmental beautification and biodiversity improvement. Previous studies on plant ecological restoration focused on aquatic plants. In recent years, with the deepening of research, scholars at home and abroad have turned their attention to constructing river banks and buffer zones, so as to intercept pollutants. Under that situation, a large number of terrestrial plants are needed. However, scholars seem to be more interested in arbors, herbs and flower plants. There is little research on shrubs, though they have abundant species, brilliant flowers, diversified seasonal aspects and different benefits.

In this paper, several shrubs commonly used in landscape greening in Northeast China are selected as research objects; their abilities of water pollutant purification are discussed. Combining with the ecological and ornamental characteristics of various plants, this paper clarifies their applicability in wetland construction, riverbank and buffer zone construction, ecological restoration, and ornamental landscape construction, in order to provide a theoretical basis for the collocated deployment of trees, shrubs and grass in ecological restoration.

2. Research Materials and Research Methods

2.1 Research materials

Among the numerous native shrub species, 7 perennial shrub plants suitable for landscape ecological construction in Northeast China were selected. They had characteristic of cold resistance, vigorous vitality, less plant diseases and insect pests, strong resistance, obvious seasonal changes and high ornamental values. One or two years old seedlings with similar plant heights and crown widths were selected. Pot culture method was used in this experiment. Seedlings were implanted in pots in early May; samples were taken from July to August. The rest of the time was used for growth

adjustment. Plants were not trimmed during the process. Test plants are shown in Table 1.

Table 1. Main habits and purposes of tested shrubs

Latin name	Main habits and purposes
<i>Amorpha fruticosa</i> Linn.	Cold resistance, drought tolerance, moisture resistance, saline-alkaline tolerance, wind prevention and sand fixation, nitrogen fixation, can be used as feed and nectar source.
<i>Spiraea japonica</i> Gold Mound.	enjoy sunshine, drought resistant, high temperature resistant, excellent cold resistant, can live through the winter safely, can form patterns
<i>Lespedeza bicolor</i> Turcz.	Drought resistance, poor soil tolerance, acid, salt and alkali resistance, can bear the trim, cold resistance; high quality green fodder.
<i>Ligustrum obtusifolium</i> Sieb.	enjoy sunshine, slightly shade tolerance, can bear the trim, fast growing and strong sprouting ability, excellent anti-pollution specie.
<i>Swida alba</i> Opiz.	enjoy humid and warmth, fast growing, leaves turn bright red in autumn; can be used as medicine.
<i>Forsythia mandshurica</i> Uyeki.	enjoy sunshine and warmth, cold and drought resistant, can tolerant barren soil, developed root system, strong water and soil conservation capacity
<i>Syringa oblata</i> Lindl.	enjoy sunshine, slightly shade tolerance, enjoy warmth and humid, one of the famous ornamental flower plants; leaves can be used as medicine

2.2 Research devices

Plastic flowerpots with top diameter of 30 cm and height of 28 cm were used as the container. A water collecting space of 2cm height was separated by a filter at the bottom of each pot, so as to collect water samples and detect the concentrations of water pollutants. 2Kg vermiculite which was washed by water and dried for many times was placed in each pot with the same density as the medium, in order to prevent other pollutants and pests. All devices were covered by a canopy to avoid the influence of precipitation outdoors.

2.3 Research methods

Since the transplanting, the growth has been adjusted for nearly 2 months until the plants grow steadily. Without considering the influence of heavy metals and other pollutants, raw water samples of TP (total phosphorus), TN (total nitrogen) and COD (chemical oxygen demand) were prepared through reagents, include KHCO_3 , KH_2PO_4 , CH_3COONa , NH_4Cl and glucose, and tap water in the laboratory. The raw water was slowly irrigated; the growth period of 7 days was set as a sampling test cycle. The treatment was repeated for three times with no plants and clear water as control group (CK). The concentrations of pollutants in raw water are shown in Table 2.

Table 2. Pollutant concentrations of water samples (mg/L)

Watering times	TP	TN	COD
Watering times			
The first time	2.03	39.8	59
The second time	2.08	40.2	60
The third time	1.95	40.3	61
The fourth time	1.94	40.0	60
The fifth time	1.98	40.4	60

The national standard method is used for the detection of TP, TN and COD. The purification rate

of each pollutant is expressed as follows:

$$\text{Purification rate} = (C_0 - C) / C_0 \times 100\%$$

In above formula, C_0 is the concentration of pollutants in raw water (mg/L); C is the sampling concentration (mg/L).

3. Results and Analysis

Plants' sewage purification mechanism is mainly embodied in three aspects. Firstly, the nutrients in sewage are directly absorbed and utilized; secondly, oxygen is transported to the root zone to meet the needs of microbial growth, reproduction and degradation; thirdly, the hydraulic transmission capacity of the medium is enhanced. In this study, pollutants were purified mainly through the first way. This is because, with vermiculite as planting medium, researchers can inhibit the influences of rhizosphere microorganisms on sewage purification due to nitrification, denitrification and other factors, eliminate the influences of nutrients such as P, N in the soil, and avoid the effects of soil pH value on observation. Therefore, the experiment can reflect the sewage purification abilities of several plants.

3.1 TP purification effects

As shown in Figure 1, the purification rates of TP are higher in all experiment groups than in the control group. The purification rate show a declining trend then keep constant with time passing by. From the results of sampling at the 35th day, it can be seen that *Spiraea japonica* Gold Mound has the best purification effect on TP with the purification rate of nearly 65%. The purification effect of *Amorpha fruticosa* Linn is also remarkable, reaching 62.54%. The purification effects of other plants are weaker than them. There are significant differences among different plants ($P < 0.05$). Overall, the TP purification abilities of shrubs go as following: *Spiraea japonica* Gold Mound. > *Amorpha fruticosa* Linn. > *Swida alba* Opiz. > *Ligustrum obtusifolium* Sieb. > *Lespedeza bicolor* Turcz. > *Syringa oblata* Lindl. > *Forsythia mandshurica* Uyeki.

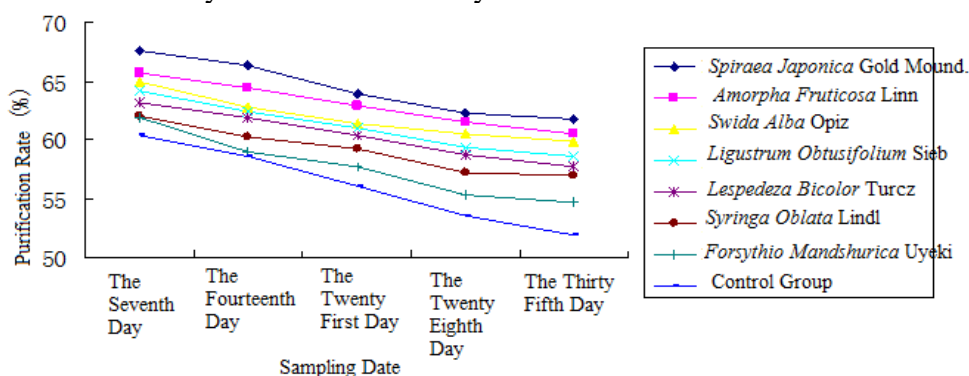


Figure 1. TP purification rates of different plants

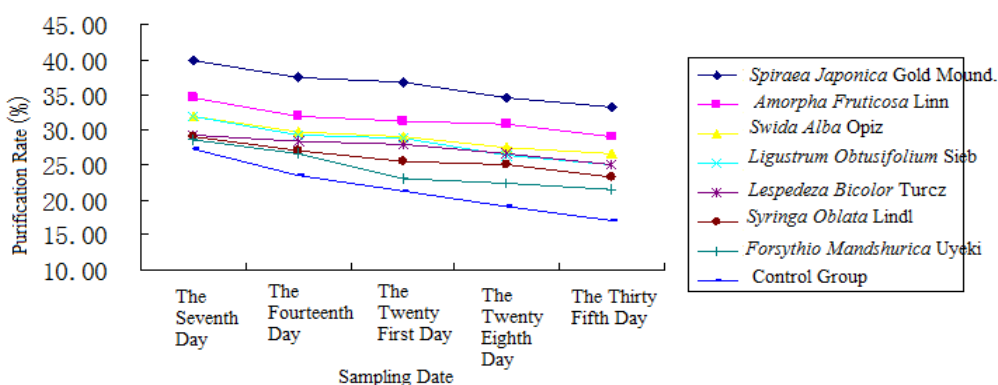


Figure 2. TN purification rates of different plants

3.2 TN purification effects

As shown in Figure. 2, the purification rates of TN are obviously higher in all experiment groups than in the control group. The purification rates also show a declining trend then keep constant with time passing by. From the results of sampling at the 35th day, it can be seen that *Amorpha fruticosa* Linn has the best purification effect on TN with the purification rate of 36.28%. The purification effect of *Spiraea japonica* Gold Mound is also remarkable, reaching 32.12%. The purification effects of other plants are weaker than them. There are significant differences among different plants ($P < 0.05$). TN purification abilities of shrubs go as following: *Amorpha fruticosa* Linn. > *Spiraea japonica* Gold Mound. > *Lespedeza bicolor* Turcz. > *Ligustrum obtusifolium* Sieb. > *Swida alba* Opiz. > *Forsythia mandshurica* Uyeki. > *Syringa oblata* Lindl.

Some studies have shown that, *Amorpha fruticosa* Linn can fix nitrogen. Among several shrubs tested in this study, *Amorpha fruticosa* Linn has the best purification effect on TN.

3.3 COD purification effects

As shown in Figure 3, the purification rates of COD are higher in all experiment groups than in the control group. The purification rates also show a declining trend then keep constant with time passing by. From the results of sampling at the 35th day, it can be seen that *Spiraea japonica* Gold Mound has the best COD purification effect with the purification rate of 43.34%, followed by *Swida alba* Opiz of 41.59%. There are significant differences among different plants ($P < 0.05$). The overall trend is *Spiraea japonica* Gold Mound. > *Swida alba* Opiz. > *Syringa oblata* Lindl. > *Amorpha fruticosa* Linn. > *Lespedeza bicolor* Turcz. > *Ligustrum obtusifolium* Sieb. > *Forsythia mandshurica* Uyeki.

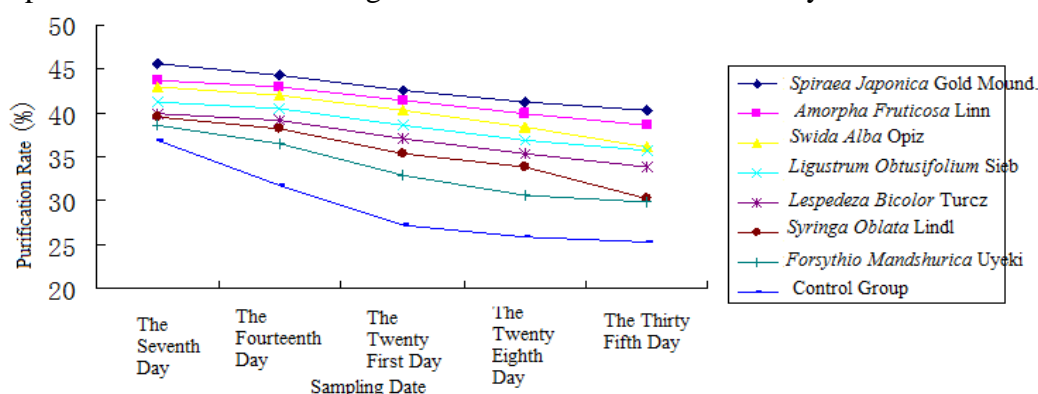


Figure 3. COD purification rates of different plants

3.4 Effects of sewage on plant growth

Resistance is an important index in material selection. Through observation and records, it is found that the growths of plants are basically good. No lodging, wilting, yellowing and other diseases occur during the test. It can be seen that all plants have certain resistance and adaptability to sewage. During their growth process, pollutants in sewage can be absorbed and utilized as nutrients. Changes in number of leaves are also recorded and compared with the mean value of the same shrub.

From Table 3, it can be seen that the growth of plants in sewage is better and slightly faster than plants irrigated in clean water, indicating that the experimental concentration of sewage cannot inhibit the growth of plants. Moreover, P, N and other elements can provide certain nutrients for plants. In the control group of clear water, the growth of plants is slow because they are lack of nutrients.

Table 3. Comparison of the number of leaves under irrigation conditions of clean water and sewage (pieces)

Plant names	Changes of the number of leaves (clean water/sewage)				
	7th day	14th day	21st day	28th day	35th day
<i>Amorpha fruticosa</i> Linn.	487 / 492	490 / 498	492 / 506	495 / 511	499 / 524
<i>Spiraea japonica</i> Gold Mound	67 / 68	69 / 70	71 / 73	72 / 76	72 / 76
<i>Lespedeza bicolor</i> Turcz.	126 / 128	126 / 132	129 / 138	132 / 141	132 / 144
<i>Ligustrum obtusifolium</i> Sieb.	202 / 198	204 / 206	208 / 217	208 / 219	212 / 226
<i>Swida alba</i> Opiz.	62 / 64	65 / 68	69 / 73	74 / 72	75 / 78
<i>Forsythia mandshurica</i> Uyeki.	104 / 105	106 / 109	111 / 114	115 / 123	121 / 127
<i>Syringa oblata</i> Lindl.	113 / 115	115 / 119	119 / 126	122 / 131	126 / 139

4. Conclusion and Discussion

Plants' sewage purification mechanism is mainly reflected in three aspects: firstly, the nutrients in sewage can be directly absorbed and utilized; secondly, oxygen can be transported to the root zone to meet the needs of microbial growth, reproduction and degradation; thirdly, the hydraulic transmission capacity of the medium can be enhanced. In this study, all shrub plants show purification effects on TP, TN and COD in sewage, which is the combined effect of plant materials and vermiculite medium. With time passing by, vermiculite cannot absorb pollutants any longer, so the purification rate decreases to a stable level. In addition, because of the limited space of container, the growth of plant roots is restrained to a certain extent. In practical application, due to differences in soil conditions and rhizosphere microorganisms, the purification rates may be slightly different from this study.

Spiraea japonica Gold Mound has good purification effects on all pollutants, which may be related to the reproduction and development of arbuscular mycorrhizal fungi (AMF) in rhizosphere environment. *Amorpha fruticosa* Linn has characteristics of strong cold and wind resistance, fast growth and long growth period, and less plant diseases and insect pests. It is often used in landscaping and road slope protection because of its beautiful shape and strong soil and water retention capacity. It is also a source of nectar and feed plant. Some data show that *Amorpha fruticosa* Linn is a kind of nitrogen-fixing plant. It has significantly higher biomass than other species, with higher demand for N and strongest TN purification ability. In autumn, the leaves turn bright red, with scattered small, white fruits growing. After deciduous, the branches become as red as coral. It is a rare plant with ornamental stems, and a kind of tree commonly used in gardens and landscape construction. In recent years, there is no report on its sewage purification effects. In this study, its purification of COD is not as good as *Spiraea japonica* Gold Mound, but better than other materials.

The results show that, *Spiraea japonica* Gold Mound and *Amorpha fruticosa* Linn have the best purification effects on TP; *Amorpha fruticosa* Linn and *Spiraea japonica* Gold Mound have the best purification effects on TN; *Spiraea japonica* Gold Mound and *Swida alba* Opiz have the best purification effects on COD. Other shrub plants are slightly inferior to them, of which the purification effects of *Forsythia mandshurica* Uyeki are the most unsatisfactory, but also significantly better than those of the control group. The purification rates show a declining trend and then keep constant with time passing by.

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