Establishment of trees in the subsidence trough filled with fly ash in Huaibei mining ares[1]

by

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ABSTRACT Fly ash filled subsidence is a practical method for subsidence land reclamation in China. About 200 hectares of subsided lands have been reclaimed by this method Huaibei mining area. This p[paper introduced the reclamation technique and its effectiveness. About 200 species of trees and shrubs were planted in the experiment site of 40 hectares which were reclaimed by this method in Huaibei Coal Mine Bureau. Among these species, 18 excellent species of trees such as locust, poplar, weeping willow were identified. The 5-aged locust had an average trunk diameter of 14.1cm and an average height of 7.6cm. The result showed that trees could grow very well on the subsided lands filled with fly ash.

Another outstanding effectiveness of this reclamation method was that the trees planted in the reclaimed lands could absorb many kind of toxic elements such as lead, fluorine and mercury from the fly ash, which eliminated the environment pollution. Also, the establishment of trees on the subsided land filled with fly ash could decrease the temperature of the soils and atmosphere, clean the air polluted by fly ash and control erosion of the reclaimed lands.

Additional key words: trees, fly ash, subsidence trough, reclamation

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1. Introduction

Coal mining causes the earth's surface of mined areas to subside. Huaibei Coal Mine Bureau has planted 200 ha of subsiding areas with 206 varieties of trees. It can not only reforest the mine areas, recover the scenery, and improve the ecological environment, but also grow wood to increase income and support the coal mine's construction. Moreover, the strong root systems of the trees can check winds and control the fly ash, absorb the poisonous substances in the fly ash, and therefore, purify the environment. In the past five years we have studied five varieties, their growing patterns and the distribution of the roots. We have also found its roles in improving the environment. In a word, we have achieved good benefits in the economy, society and environment.

2. Materials and Methods

The experimental area is situated in the north of Anhui Province at latitude 33° 56'N and longitude 116° 47'E. The annual average temperature is 14.5°C and annual rainfall amounts to 829.5mm. The sunshine here reaches 2315.8h yearly, the relative humidity is 70 percent, and frost-free period is 202 days.

The experimental area is formed by filling the subsiding area with 4-5 meters of fly ashes which is covered with 30cm of soil. Those grains of coal ash whose diameters are between 0.005mm and 2mm take up 90%, the rest are less than 0.005mm. Their unit weight is $0.81 g/cm^3$, the porosity is 61.42%, and permeating speed of water reaches 6.48mm/min. The ashes do not hold water and manure well.

In the fly ashes, the chemical compositions Sio_2 and Al_2O_3 take up 80%, next are Fe_2O_3, CaO, MgO and K_2O.

The nutrients in the ashes (%) are $N_{0.004}$, $S_{0.23}$, $P_{0.044}$, $K_{0.69}$, $Ca_{1.44}$, $Mg_{0.24}$.

The trace elements (PPM) are: Fe_{115}, $B_{119.4}$, $Mn_{141.6}$, $Cu_{89.3}$, $Zn_{474.7}$, and $Mo_{6.5}$.

The pernicious elements (PPM) are: $As_{4.3}$, $Cdl._{83}$, $Cr_{8.1}$, $Pb_{63.7}$, $Se_{1.0}$, $Hg_{0.36}$ and $F_{30.0}$.

In the spring of 1986, optimum varietiy tests were started by planting locusts, poplars, willows, elms, chinaberries and paulownias in the subsidence areas filled with fly ashes. The afforesting densities were 2X3m and 3X4m.

3. Results and Discussion

3.1 The Optimum varieties Seeking and Growth and the Trees in the Subsidence Trough Filled With Fly Ashes.

Subsidence trough filled with fly ashes is a special kind of artificial soil. From 1986 to 1990 we observed and studied the artificial forests of locusts, poplars, willows, elms and chinaberries, and selected a group of fine varieties according to their adaptability to surroundings and their growth. Their growth conditions are shown in Table 1.

In Table I varieties such as Jangsu Willow 172, Locust No. 13 and No. 42, Elm8015 and 8019 grow well in the subsidence trough filled with fly ashes. Their growth surpass the check group by 30--66%. This shows that in order to bring the variety potential into full play, we must choose the variety carefully and pick up fine asexuality. For example, locust is the most suitable variety in this soil, while asexuality No. 13 grows most luxuriantly and its growth amount reaches 160% within 3 years. In 1990, we made an

investigation into the 5 year old 3X4m locust No. 13, its average trunk diameter was 14.1cm, the widest one reached 18cm, and its height was 7-9m.

Table I.

The Growths of Trees in Subsidence Trough Filled with Fly Ashes

Varieties	Asexuality	Age	Diameter		
		Year	Growth Amount	Annually Average	%
Poplars	I-74/76	4	13.70	3.45	130
	108	4	12.56	3.14	110
	1-72	4	10.62	2.65	100
Willows	Jiang su Willow 172	4	11.79	2.95	160
	Jiang su Willow 194	4	10.20	2.57	140
	Dryland Willow	4	7.35	1.84	100
Locusts	No. 13	4	14.72	3.68	160
	No. 42	4	14.03	3.53	153
	Native Locust	4	9.20	2.30	100
Elms	8015	4	8.82	2.21	166
	8019	4	8.83	2.21	166
	Native Elm	4	5.32	1.33	100

3.2 The Distribution of Root Systems in the Fly Ashes

When we afforest in the reclaimed area filled with fly ashes, understanding the growing conditions and distribution sphere of root systems is the important basis for plans to apply fertilizer, irrigate and soil improvement techniques. In May and June of 1991 and 1992, we surveyed the root distributions of 4 year-old locusts, poplars, willows and elms. The findings are indicated in the four diagrams below.

Figure 1. Vertical root distribution of the Poplar

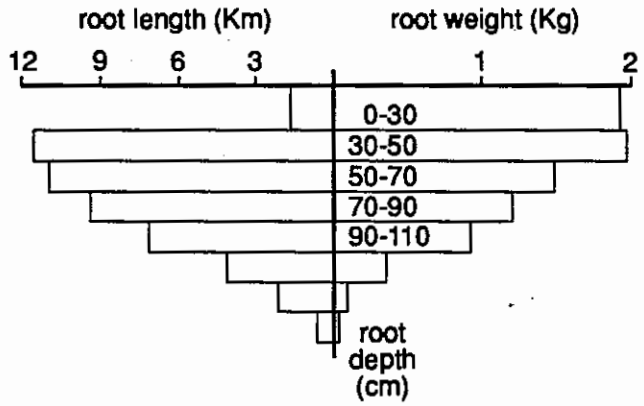

Figure 2. Vertical root distribution of the Willow

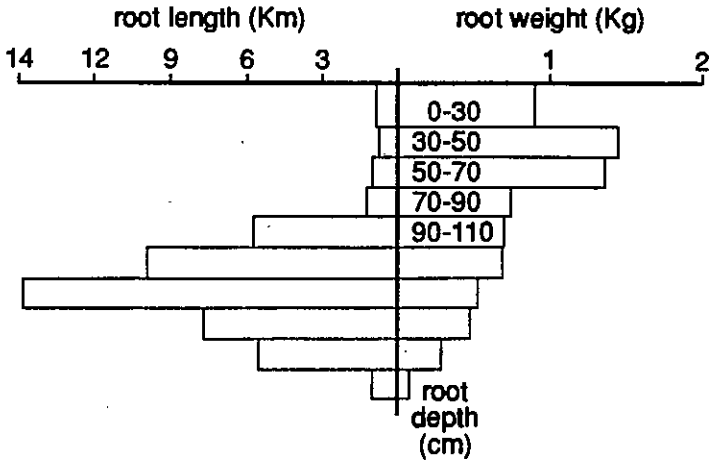

Figure 3. Vertical root distribution of the Locust

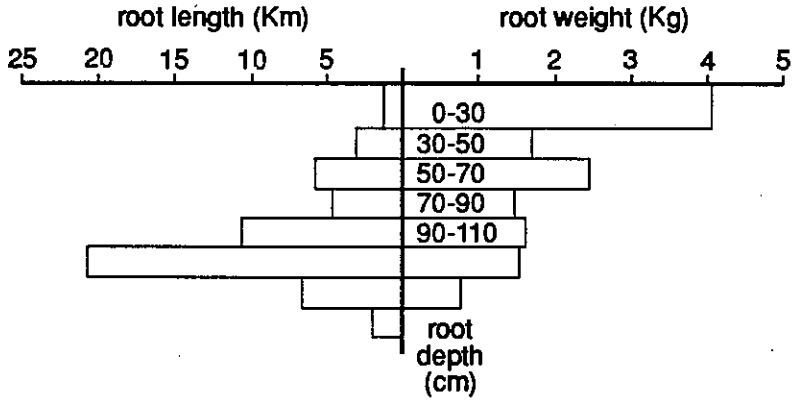

Figure 4. Vertical root distribution of the Elm

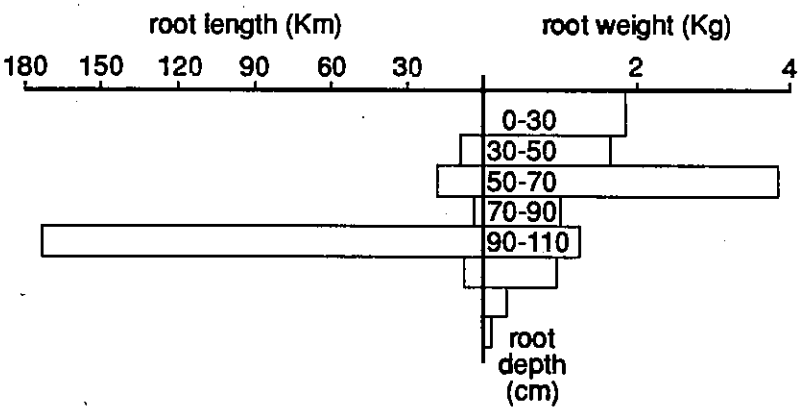

Table 2.
Capacity of Different Trees and Their Organs Absorbing Pernicious Elements

Varieties	Organs	F	Cr	Cu	Pb	Cd	Hg	As
Willows								
	Leaves	02.47	1.40	3.92	Δ	Δ	0.63	Δ
	Branches	110.07	Δ	3.16	11.20	Δ	0.63	15.70
	Roots	48.93	16.53	2.29	10.69	Δ	0.00	20.80
Locusts								
	Leaves	185.57	2.16	3.36	13.54	Δ	0.38	14.90
	Branches	18.58	Δ	1.54	5.47	Δ	0.17	Δ
	Roots	8.83	1.12	4.04	Δ	Δ	0.12	5.80
Poplars (107)								
	Leaves	140.40	Δ	8.94	16.41	0.41	0.42	Δ
	Branches	28.91	Δ	4.11	7.94	Δ	0.72	12.90
	Roots	22.72	2.99	6.97	11.20	Δ	0.38	Δ
Chinaberries								
	Leaves	130.58	Δ	1.95	13.35	Δ	0.19	10.00
	Branches	20.16	0.74	2.05	14.01	Δ	0.33	6.30
	Roots	33.87	6.29	7.69	15.43	Δ	0.14	1.20
Elms								
	Leaves	141.74	Δ	4.45	70.83	2.30	0.44	33.90
	Branches	16.93	Δ	Δ	20.53	1.26	0.23	68.40
	Roots	14.50	Δ	2.93	38.66	1.54	0.47	Δ

Note: "Δ" means that the result has not been (tabulated).

In the analysis we know that these five varieties of trees have the best capacity in absorbing. Willows' and locusts' absorb 250--212.98mb/kg at most. As for Pb and As, willows and locusts also absorb a large amount, elms absorb 130.02 mg/kg. For Cd, all varieties except elms whose adsorption amounts to 7.10 mg/kg, have poor absorption.

According to our results, one ha of forest of 2 year-old willows can absorb F 4663.17_g, As 631.29_g, $Pb_{443.03g}$, $Cu_{1258.46g}$, $Hg_{25.4g}$. This shows that afforestation in reclamated areas will play an important role in purifying the environment of coal mines.

3.4 Afforesting in the Reclamated Areas and Regulating the Climate

Many years of research have proved that afforestation in the reclaimed areas will quickly form a forest microclimate, change the scenery of coal mines and create a better living environment for people. The temperature in the locust-willow forests in the subsidence areas of Huaaibei coal mines drops an average of 3.7°C - 9.3°C, and the daily average ground temperature falling to 4.36°C - 7.5°C. In the No. 2 Mine of Pingdingshan Coal Mine Bureau, Henan Province, the difference of temperature between the bare waste-rock hills and waste-rock hills covered with forests is 10.7°C - 13.3°C. In the institute of Forestry Science with Fushun Coal Mine Bureau, Liaoning Province, researchers measured the temperature of both bare and forested hills, the difference reaches 15°C - 18°C in summer. Those forests provide people with a cool environment in hot summers and are also good for other plants.

Since the fly ashes are light and of small particle size, they are easily carried by wind causing air pollution. The luxuriant foliage of forests will (absorb and stick) some fly ashes, thus purifying the air and protecting the environment. The Monitoring Station of Environmental Protection in Huaibei City has measured TSP (traveling suspended particles) and declared the suspended particles in willow-locust forests is reduced to 42.93% compared with that of bare ground areas.

4. Conclusion

4.1 We have succeeded in afforesting in the reclaimed areas of fly ashes. Locust and poplar are the best varieties, the next are chinaberry, elm and tree of heaven.

4.2 The root systems of these main varieties can grow well and distribute widely in fly ashes. Poplar root groups spread in the 30-110 cm deep fly ashes, locusts' and willows' are in 90-150 cm, and elms' in 50-100 cm ash layer.

4.3 Afforestation in the reclamated area of fly ashes can decrease poisonous elements and purify the environment. For example, 1 kg elm can adsorb 428.29 mg of pernicious elements F, Cr, Pb, Hg, Cd, As and Cu. 1 Kg chinaberry can adsorb 402.28 mg of various pernicious elements, and 1 ha forest of 2 year-old locusts can adsorb 2.68 kg of various harmful elements.