THE APPLICATION OF PHYTOREMEDIATION TECHNOLOGY ON ECOLOGICAL REMEDIATION IN CHINA STRIP MINES

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ABSTRACT

Strip mines in China are mainly located in the three Northeastern provinces, Inner Mongolia Autonomy Zone and Guang Dong province. A great amount of strip materials will be produced during the mining exploitation with a general 5~10 cubic meter solid wastes per 1 ton. Those amount of spoiled wastes not only take huge land space, but also cause ecological environment devastation of mining area, represented by the reduction of soil pH value and obvious increasing of heavy metal content in soil. The paper has researched on phytoremediation technology based on Fushunxi Strip Mine in Liaoning province and Maoming oil shale strip mine in Guangdong province. Fushunxi Strip Mine has adopted phytoremediation technology by selecting spruce, Beijing peach and soapbark. After restoration, the basic physicochemical property of mining soil has turned better, the PH value increases from the range of 5.12 ~ 6.00 and becomes stable within the alkalinity range of 7.4 ~ 8.2, and the contents of Pb, Cd, Cu and Zn decreased effectively. Maoming oil shale strip mine has adopted rich acacia, jarrah and pine to restore the soil. After the 18a restoration, the soil organic content increased 50% ~ 50.39% effectively, and soil pH value increased slowly from the range of 3.74 ~ 4.52 to the range of 4.45 ~ 5.51.

Key words: phytoremediation, strip mine, ecological remediation, West Fu Shun strip mine, Mao Ming oil shale strip mine.

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INTRODUCTION

Strip mines in China are mainly located in the three Northeastern provinces, Inner Mongolia Autonomy Zone and Guang Dong province. A great amount of strip materials will be produced during the mining exploitation with a general 5~10 cubic meter solid wastes per 1 ton. Those amount of spoiled wastes not only take huge land space, but also cause ecological environment devastation of mining area, represented by the reduction of soil pH value and obvious increasing of heavy metal content in soil.

Heavy metals and organic pollutants in soil have featured hard solution and long endurance. Phytoremediation technology can reduce the toxic degree from the environment. Phytoremediation refers to a solution which takes advantage of green plants to absorb and take away the heavy metal to reach the no harmful effect, and it is considered as an economic, effective and environment friendly technology. According to restoration mechanics, phytoremediation can be divided as phytons removal process and phytons stabilization process, and phytons removal process can be subdivided into five processes, phytons extraction, phytons volatility, phytons degradation, and rhizosphere microbe degradation[1]. The paper has researched on phytoremediation technology based on Fushunxi Strip Mine in Liaoning province and Maoming oil shale strip mine in Guangdong province.

PHYTOREMEDIATION IN FUSHUNXI STRIP MINE

Natural geographic environment

Fushunxi Strip Mine is located in the utmost west of Fushun coal field. Fushun city is located in the river valley of the eastern mountains in Liaoning province, with moderate continental climate featured frigidity and humectation. The region is affected considerably by wind and landform. In spring, the wind is strong and dry; in summer, the wind comes from southeast with moist and rain; in autumn, it is quite cool and wet and dry adequately; in winter, it becomes cold and dry affected by air flow from Inter Mongolia plateau and Siberian. The average annual temperature is 8.1°C, the highest and lowest temperature are 40.3°C and -35.2°C respectively.

Phytoremediation effect in Fushunxi Strip Mine

Fushunxi Strip Mine is the largest one in Asia. The mine is crossing over Xinfu and Wanghua administrative districts of Fushun City. The distance from east to west is 6.6 km and 2.0 km from north to south; the whole area covers 10.87 km^2 and the ultimate mining depth is 480m. The history of Fushunxi Strip Mining can trace back to 82 years ago, and the production reached 270 million tons of high quality coal and 500 million tons of oil shale from 1914 to 2000; meanwhile, the total solid wastes accompanied reached 1.65 billion cubic meters, covered 20.20km^2 space and reached 100m above ground.

Fushunxi Strip Mine selected spruce, Beijing peach and soapbark to conduct phytoremediation. After restoration of one year, the soil physicochemical quality is analyzed in the following table 1.

Table 1.: Soil physicochemical property changes before and after phytoremediation in Fushunxi Strip Mine[1]

	pH	Water Content [%]	Salt Content [%]	Organic Content [%]	CEC [cmol/kg]
before remediation	5.12~6.00	3.4~4.1	0.175~0.300	36.32~48.24	21.38~24.12

spruce	7.43	2.3	0.125	21.05	18.47
Beijing peach	7.93	2.5	0.025	9.47	18.22
soapbark	8.20	2.1	0.033	12.58	18.58

Before phytoremediation, we can infer from table 1 that the soil is acidic with PH value from 5.12 to 6.00 due to the oxidation of sulfide in the dumping wastes; water content of soil is 3.4% to 4.1% with poor water conservation; the organic carbon is rather high with a range of 36.32% to 48.24%; the salt content is from 0.175% to 0.300%, which is inclined to salinization.

After phytoremediation, pH value of soil increased to 7.43~8.20, which is within the adequate growth range of most phytons. Water conservation of soil doesn’t vary much with a range of 2.1%~2.5%; salt content decreases significantly with a range of 9.47%~21.05%; average value of cation exchange capacity is 18.78cmol/kg, which indicates significant improvement of physicochemical property of soil.

Meanwhile, different phytons have different remediation effects towards different heavy metals. The removal ratio is as table 2 indicates after phytoremediation.

Table 2.: Heavy metal removal ratio after phytoremediation in Fushunxi Strip Mine(%) [2]

	Cd	Cu	Pb	Zn
spruce	91.5	65.4	60.7	60.2
Beijing peach	93.8	40.6	31.5	0.7
soapbark	94.2	52.9	59.4	0.9

From table 2., we can see that the content of heavy metals decreased obviously after phytoremediation. The removal effect of Cd is best, Cu and Pb are better and Zn is good. Comparing different phytons with removal effect,the rank is spruce> soapbark> Beijing peach.

PHYTOREMEDIATION IN MAOMING STRIP MINE

Physiographical condition

Maoming city is located in the edge of tropical zone and its climate is tropical monsoon wind and oceanic. The yearly average temperature is 23.2°C, the average temperature in January is 15.0°C and the lowest is 1.7°C, and the whole year is free-frost. The average temperature in July is 28.4°C, and extreme highest is 37.8°C. The total yearly rainfall is 1567mm, and the rainfall from April to September accounts for 84% of total yearly rainfall.

Phytoremediation effect in Maoming Strip Mine

China is rich in oil shale resources; the positive ore is 4.83×10^{11}t and ranks 4^{th} in the world. In Guangdong province, the positive ore of oil shale resources reaches 7.57×10^{9}t and ranks 2^{nd} in China. The reserve of oil shale in Maoming City is 5.10×10^{9}t and it has been exploited since 1950s. The total solid dumping wastes reach 2.4×10^{8}t during the exploitation, take space about 8.1km^2 and waste slag is 30~40m above the ground. The bare solid dumping wastes pollute surrounding atmosphere by dust. The content of heavy metal and sulfide in such dumping wastes are rather high, but the content of Ca and Mg are relatively low and the pH value of leachate is below 3, and the strong acid water heavily polluted surrounding farms and fish ponds.

From 1985, Maoming petrochemical corporation began to plant rich acacia, jarrah and pines to conduct phytoremediation test[3,4]. The soil physicochemical property before and after phytoremediation is referred to in table 3.

Table 3.: Soil physicochemical property before and after phytoremediation in Maoming oil shale strip mine.

	pH	Water content [%]	Organic Carbon [%]	TN [%]	TP [%]
before	3.74~4.52	12.6	0.2~7.75	0.007~1.85	0.01~0.14
after	4.45~5.51	25.2	0.4~11.84	-----	-------

From table 3., we can see that the pH value of soil increased from the range of 3.74~4.52 to 4.45~5.51,and the increasing extent is not too. Water content and organic carbon increased obviously, this change is opposition to that in Fushunxi Strip Mine. With the extension of phytoremediation period, the organic carbon in dumping wastes increased, and the soil physicochemical property is significantly improved.

After phytoremediation, the removal ratio of different heavy metals is as table 4.

Table 4.: Heavy metal content in soil before and after phytoremediation in Maoming strip mine [mg/kg].

	Cd	Cu	Pb	Zn	Cr
Before	0.058~0.115	12.52~28.44	30.30~52.27	24.36~98.30	16.17~20.00
After	0.036	10.5	24.0	22.0	9.0
Removal ratio（%）	37.9~68.7	16.1~63.1	20.8~54.1	9.7~77.6	44.3~55.0

From table 4., the metal content of soil after phytoremediation declines respectively; removal ratio of Cd is 37.9%~68.7%, Cu is 16.1%~63.1%, Pb is 20.8%~54.1%, Zn is 9.7%~77.6% and Cr is 44.3%~55.0%. From early 1993, Maoming petrochemical corporation constructed a layout of forest park and built gardens on oil shale dumping wastes to improve the surrounding ecological environment. Practices have achieved better environmental and social effects.

CONCLUSIONS

Through case analysis of phytoremediation in Fushunxi strip mine and Maoming oil shale strip mine, it is feasible to perform ecological remediation on solid wastes by selecting appropriate plants. After a certain period of phytoremediation test, soil physicochemical property is improved and heavy metal content declines distinctively. By comparisons of two phytoremediation tests, it takes shorter time to remedy Fushunxi strip mine, the soil water content and organic carbon don't vary distinctively; as for Maoming strip mine, after as long as 20 years of phytoremediation, all soil physicochemical properties, especially the soil water content and organic carbon improved significantly, solid wastes are converted into newly formed soil with a certain fertility. The two cases provide theoretical and practical evidence to remedy and reclaim degenerated ecological environment.

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