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Research Paper

Experimental research for riverbank restoration by using soil bioengineering

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Abstract: Soil bioengineering is a means to assess, design, construct and maintain living vegetation systems, to repair damage caused by erosion and land failures and to protect and enhance functioning systems. Although China considers being the first country by using soil bioengineering for river management, knowledge and research on this area is very scantiness. We here report an experimental site in Huaijiu River, Beijing. It proves that *Salix alba var.Tristis* is good material to obtain near-natural riverbank restoration. Soil bioengineering measure of wattle fence is effective. After periods time of project implementation, significant effectiveness was obtained on slope stability, habitat improvement, and ecological restoration of river banks. This can provide guidelines for selecting materials and methods to control riverbank erosion. It was concluded that the approach could be widely applied in ecological riverbank restoration in China.

Keywords: Soil bioengineering, riverbank restoration, wattle fence, *Salix alba var.Tristis*

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Introduction

Rivers run through country sides like blood vessels and veins through the human body. Similar to the blood vessels they have a life supporting function. The water body itself, the river bed, the riparian zones, and vegetation in the immediate surroundings of each water body represent valuable and interdependent habitats for specific fauna and flora.

Using technical measures and "hard" materials (concrete and impermeable stone walls with smooth surfaces), the water bodies' courses have been straightened and disconnected from their environment. Riparian vegetation has been eliminated and the water body continuity has been disrupted. These measures had detrimental impacts on the water bodies' hydrology, morphology and the ecosystems.

Soil bioengineering is an integrated technology that uses live plant materials to provide erosion control, slope and stream bank stabilization, landscape restoration, and wildlife habitat (Gray, DH. et al. 1982). This technique can be used alone or in conjunction with conventional engineering techniques. It aims at re-establishing the water body's continuity, the transversal connection to the riparian zone, the vertical connection to the underground and endogenous morphological processes so that the water body can again fulfil its ecological service and protection functions.

China is thought to be the first country by using soil bioengineering for dike repair as early as 28 BC (Barker D.H et al. 2004). But it has long been forgotten in the history. This technique has come to a biggest boost for being used in all kinds of slope problem treatment in recent years. We here report an experimental site in Huaijiu River, Huairou district, which is the suburban of Beijing, China. This project was using soil bioengineering method to generate riverbank restoration and soil and water conservation.

Martial mad Methods

Site location

Experimental area is located at Huaijiu River, Huairou district of Beijing, China. Huairou district, between 40°14'~40°04' N and 116°17'~116°53' E, which is situated at northern Beijing, is known for being one of the most important water sources in the capital city earmarked for protection. Huaijiu River is a permanent stream with river slope range from 2.1‰ to 2.5‰. A length of bare riverbank treated with jackstone was selected to use soil bioengineering for restoration. Willow fence has been applied along the riverbank in the March of 2008. Before implementation of the project, this area was suffered from serious soil erosion. Organic matter content of soil is 12.203 g/kg. Few birds or aquatic were nearby (shown in Figure 1).

Figure 1. Experimental area before soil bioengineering construction in Huaijiu River

Plant material and soil bioengineering technique

Plant material: According to the principles of selecting soil bioengineering plant materials (Donat, 1995), native plant species of *Salix alba var.Tristis* was used.

Soil bioengineering technique: based on the field situation, we choose the methods of wattle fence which has the advantage of easily retain and stop moving soil as well as a flexible and rapid step towards climax-like vegetation. Schematic diagram is shown in Figure 2. Materials for this kind of technique are wooden stakes, steel rods or living cutting of 0.5-1.0m in length, twigs of shoot-forming species suited for weaving of 3-5m in length, backfill soil, perhaps prefabricated wattle work.

This kind of technique has been around since the Bronze Age in Europe and the British Isles to make roofs, walls and fences to contain livestock such as sheep. Nowadays it can be used for slope stabilization and to retain topsoil cover as well as for bank protection. First stakes are driven vertically into the ground at approx.50cm distance. Living twigs are then woven around the stakes and their thicker ends burled at least 20cm deep in the ground. The fences are backfilled with soil apt for vegetation to prevent them from drying out. The best season for construction is during winter dormancy and at the beginning of vegetation period. Time required is 15min. /m.

Monitoring and survey

Monitoring and survey is quite important to value the growing condition of plants and the effect of soil bioengineering for riverbank restoration. Parameters include the base diameter and the length of terminal shoots. Four months after implementation, an artificial rainfall test under 3mm/min rainfall intensities has been done to analyze the ability of Salix alba var.Tristis wattle fence against slope erosion. Organic matter content of soil was measured three years after construction. The boost of biological diversity can show creature restoration situation.

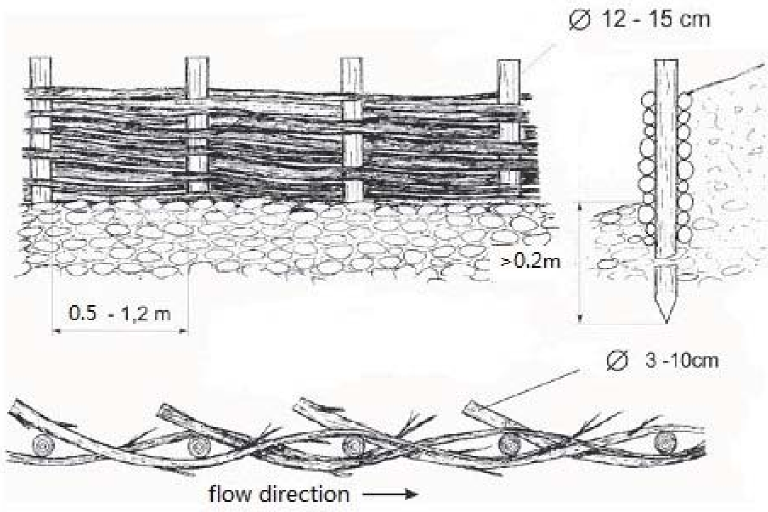

Figure 2. Schematic diagram of wattle fence

Results

Plant performance

Vegetation performance is the first sign of whether soil bioengineering a success or failure. Willow began to sprout and grow roots one month after construction. Amount of newly born branches is 170 per square meter two months after implementation.

Base diameter and shoot length can indicate the plants performance directly and the ability of slope stability indirectly (Schiechtl H. 1980). Through two-year continues investigation, results show that *Salix alba var.Tristis* wattle fence grew very well. Base diameter is 46.1±9.0 cm, 128.2±41.8 cm, 148.5±59.0 cm and 212.1±113.0 cm for 2 months, 5 months, 13 months and 20 months after construction respectively. And for the height of shoot length are 0.4±0.06 cm, 0.76±0.76 cm, 0.86±0.31 cm and 1.51±0.93cm respectively. *Salix alba var.Tristis* under the measure of wattle fence shows high level of growth.

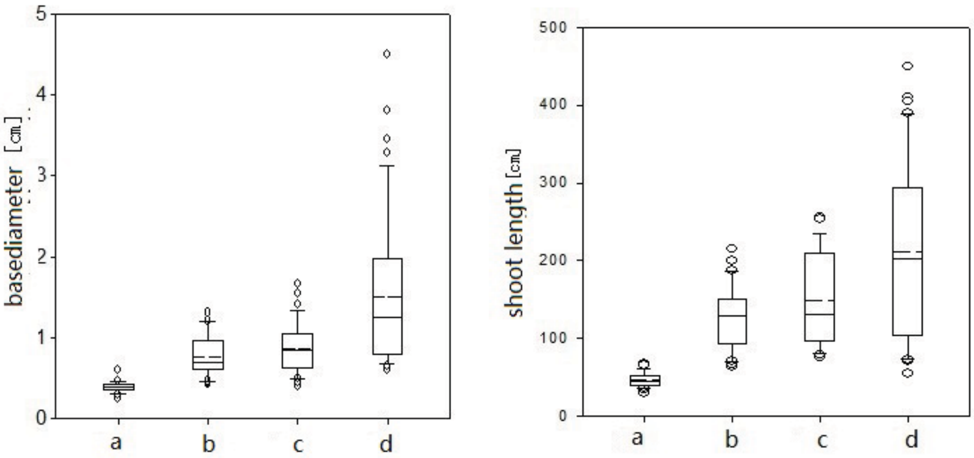

Figure 3. Base diameter and shoot length of *Salix alba var.Tristis* wattle fence after construction (a=2 months, b=5 months, c=13 months, d=20 months)

Habitat improvement

Restoration of a natural area includes planting of native species - grasses, wildflowers, plants, trees. This gives the natural ecosystem its building blocks towards recovering its natural state (Edson JL. et al. 1995). Figure 5 below shows the changes of wattle fence in the experimental area. By applying soil bioengineering technique, our experimental site has achieved environmental benefits of erosion control, wildlife habitat, water quality improvement and aesthetics. Birds, insect and many aquatic creatures come to live in this area. Organic matter content of soil is 17.360 g/kg three years after construction which indicates that vegetation on the slope can improve soil. Soil bioengineering helps to build an environmental friendly riverbank which can benefit not only the natural but also human beings.

Slope stabilization

Loss of riverbank vegetation can reduce the resisting forces and makes riverbank more susceptible to erosion. Vegetation can increase the soil strength through their root structure while the bio-engineered structure provides additional support (Hoag JC. 1993). Wattle fence behaved unideal at initial two months for the reason that new branches were not intensive and few plants exited on the slope. Four months after implementation, an artificial rainfall test under 3mm/min rainfall intensities has been done. Except for wattle fence, many other plants came to grow. Leafy vegetation on the experiment site helps to delay runoff-yielding time and sediment yield. Near the wattle fence experimental area, an untreated plot was selected to make comparison. According to the test, with time goes by, runoff shows significant difference between wattle fence and untreated plot. Compared with untreated plot, soil bioengineering experimental plot can reduce runoff volume by the percentage of 60.1% and runoff sediment for 65.8%. Compare process of runoff producing in the slope is shown in Figure 5. Our willow structures grow over time, further reinforcing the affected area. As the willow grows, the roots grow deeper into the area and draw out potentially destabilizing water.

Figure 4. Experimental area by using wattle fence: the day of planting (left),3 months after (middle) and 5.5 months after (right)

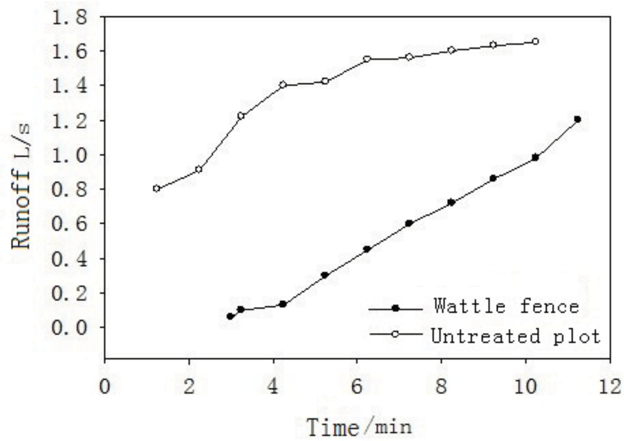

Figure 5. Process of runoff producing in the slope

Conclusion

Soil Bioengineering is common in the developing world, where population is high and land use is often intensive. *Salix alba var.Tristis* wattle fence shows high adaptation to the Beijing local environment.

Experimental site in Huaijiu River proves that: plant material of *Salix alba var.Tristis* grew well under the measure of wattle fence. Four months after construction, wattle fence can reduce 60.1% runoff and 65.8% runoff sediment compared with untreated plot. Three years after implementation, soil organic contain increase 42.26% of initial contain. Soil bioengineering systems create resistance to sliding or shear displacement in a stream bank as they develop roots or fibrous inclusions.

Acknowledgment

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