



**Abstract:** Hydroponic experiments were carried out to investigate the influence of different (Zn) and copper (Cu) levels (10, 40 mg. L<sup>-1</sup>) on the growth, malondialdehyde (MDA) content, root activity, soluble protein, contents of chlorophyll a and b, and accumulation of cadmium (Cd) in *Vetiveria zizanioides* L. when they were exposed to different Cd (15, 30 mg. L<sup>-1</sup>) levels. The results showed that except for the low level Cu treatment, the combination of Zn-Cd and Cu-Cd exhibited synergistic decreasing effects on root activity, chlorophyll, protein contents, whereas made the MDA increase in experiments. The effects of Zn and Cu on the plant assimilating Cd were complex. The combination of Zn-Cd or Cu-Cd on Cd accumulation in shoots may have antagonism effects, and on the absorbing of Cd in roots it may have synergistic or addition effects.

**Key words:** combined pollution; *Vetiveria zizanioides*; Cd accumulation; physiological characterization

## 04 Efficiency of Different Vegetative Restoration Settings Deployed on Wastelands of Zijinshan Gold-copper Mine in Fujian Province

HOU Xiao-long<sup>1</sup>, ZHUANU Kai<sup>2</sup>, LIU Ai-qin<sup>1</sup>, CAI Li-ping<sup>1</sup>

(1. College of Forestry, Fujian Agriculture and Forestry University, Fuzhou, Fujian 350002, China;

2. Fuzhou Environmental Protection Agency, Fuzhou, Fujian 350003, China)

**Abstract:** The aim of this study was to evaluate the efficiency of different vegetative restoration settings on mining wasteland. Vegetation species, quantity, coverage, species diversity and biomass were surveyed by standard plots on different treatments deployed on the mining wasteland of Zijinshan gold-copper mine in Fujian Province. The results showed that the number of vegetation species was rapidly increased at almost all the treatments, and the species number of the herb layer were significantly greater than the control after 5 year restoration. Species quantity at *Pinus massoniana*+*Lespedeza bicolor*+*Vetiveria zizanioides*+local flood turf (mode B) was the most. There were 25 species of those. Diversity index at *Liquidambar formosana*+local beach turf (mode D) and *Eucalyptus robusta*+local flood turf (mode E) were bigger than others, these two vegetation allocation modes could rapidly increase the species diversity of the community. The vegetation coverage also increased greatly. There were above 85% apart from *Pinus massoniana*+*Lespedeza bicolor* (mode A). The biomass of herb layer at *Pinus massoniana*+*Lespedeza bicolor*+*Vetiveria zizanioides*+local beach turf (mode B) was the largest, it was 15.81 times to the control. The treatments of *Pinus massoniana*+*Lespedeza bicolor*+*Vetiveria zizanioides*+local beach turf (B), *Liquidambar formosana*+local beach turf (D) and *Eucalyptus robusta*+local beach turf (E) performed considerably better than the other ones and therefore can be promoted for larger areas in the vegetation restoration of the mining wasteland.

**Keywords:** Zijinshan gold-copper mine; mining wasteland; vegetation allocation modes; recovery effect

## 05 Photosynthesis Response to Cadmium in *Vetiveria zizanioides* (L.) Nash.

GAO Wei<sup>1</sup>, WEI Hong<sup>1</sup>, JIA Zhong-min<sup>1,2</sup>, TIAN Xiao-feng<sup>3</sup>

(1. Key Laboratory of Eco-environments of Three Gorges Reservoir Region, Ministry of Education,

School of Life Science, Southwest University, Chongqing 400715, China; 2. Southeast Sichuan Geological Party, Chongqing Bureau of Geology and Minerals Exploration, Chongqing 400038, China; 3. Guangzhou Guangya Experimental Middle School, Guangzhou 510176, China)

**Abstract:** *Vetiveria zizanioides* (L.) Nash are subjected to different kinds of Cadmium treatment (0 mg/kg, 2 mg/kg, 20 mg/kg and 80 mg/kg), and their biomass, pigment content, net photosynthesis rate (Pn) and chlorophyll fluorescence parameters are investigated at 0d, 50d and 100d. The results show in the following. ① At 50 d, Cadmium conditions have facilitation on net photosynthetic rate (Pn), PS II photochemistry (ΦPSII), the electron transfer rate of PSII (ETR) and photochemical quenching coefficient (qP) of *Vetiveria zizanioides* (L.) Nash especially under 20 mg/kg. Cadmium conditions could not effectively influence the biomass, photosynthetic pigment, the potential efficiency of primary conversion flight energy of PSII (Fv/Fm) of *Vetiveria zizanioides* (L.) Nash. ② At 100d, net photosynthetic rate (Pn) goes up significantly under 2 mg/kg and 20 mg/kg but declines significantly under 80 mg/kg, PS II photochemistry (ΦPSII), the electron transfer rate of PSII (ETR) and photochemical quenching coefficient (qP) all decrease but it drops significantly only under 80 mg/kg. The above results prove that *Vetiveria zizanioides* (L.) Nash could not only tolerate Cadmium stresses with low concentration for a long time, but also endure Cadmium stresses with high concentration for a short time.

**Key words:** Cadmium stresses; *Vetiveria zizanioides*(L.)Nash; photosynthesis; chlorophyll fluorescence

## 06 Effects of *Vetiveria Zizanioides* L. Growth on Chemical and Biological Properties of Copper Mine Tailing Wastelands

XU Decong<sup>1, 2</sup>, ZHAN Jing<sup>1</sup>, CHEN Zheng<sup>1</sup>, GAO Yi<sup>1</sup>, XIE Xianzheng<sup>3</sup>, SUN Qingye<sup>1,\*</sup>, DOU Changming<sup>3</sup>

(1 School of Resources and Environmental Engineering, Anhui University, Hefei 230601, China; 2 School of Chemical and Life Science, Suzhou University, Suzhou 234000, China; 3 Anhui Institute of Environmental Science, Hefei 230061, China)

**Abstract:** *Vetiveria zizanioides* L. is a Gramineae herbaceous perennial with rapid growth and is highly adaptable to its environment. It is often found in wasteland and lead/zinc mining abandoned soil. *V. zizanioides* is also strongly adaptable to copper mine tailings. The criteria for determining successful phytoremediation focus on both aboveground vegetation and substrate characterization. To understand the effects of artificial revegetation on the remediation of wastelands associated with the Tongling copper mine tailings in Anhui Province, we studied the dynamic changes in chemical properties, microbial biomass, enzyme activity in the tailings, and the relationships between these factors. The tailings were collected under *V. zizanioides* communities constructed on copper mine tailing wastelands at different times: JX (*V. zizanioides* communities were established in the recent stage); ZX (*V. zizanioides* communities were established in the middle stage); and OX (*V. zizanioides* communities were established in the early stage). The results showed that the tailings under the ZX and OX communities, had higher pH values and lower electrical conductivity and available Cu and Pb concentrations than the tailings under the JX community, indicating that the process of tailings acidification slowed down after the establishment of the *V. zizanioides* community. As the *V. zizanioides* community developed over time, the total N and available P in the tailings at 0—5 cm and 5—20 cm depths increased; with the total N and available P in the tailings at 0—5 cm under the OX 4.64 and 22.44 times higher, respectively than at the same depth under the JX. The total N accumulation at 0—5 cm was significantly higher than at the 5—20 cm depth, indicating the effect of the phytoremediation on improving the substrate chemical properties. With increased plantation time, the dehydrogenase, catalase and urease enzyme activities and the microbial biomass C and N contents also gradually increased at the 0—5 cm and 5—20 cm depths, but the alkaline phosphatase activity did not increase. The dehydrogenase and catalase activities and the microbial biomass C and N contents were all either extremely significantly or significantly negatively correlated with the electric conductivity. However, the microbial biomass N contents and all soil enzyme activities were significantly positively correlated to the total N content, indicating that total N was a dominant influence on soil enzyme activities. The microbial biomass and most soil enzyme activities decreased with increasing Cu and Pb contents, and the dehydrogenase and catalase activities were most sensitive to Cu, but less sensitive to Zn. The *V. zizanioides* has shown a significant ability to improve the chemical properties of tailings, and also to increase microbial biomass and soil enzyme activities. It is an adaptive plant species, and is recommended for the ecological rehabilitation of copper mine tailing wastelands.

**Key Words:** *Vetiveria zizanioides* L.; copper mine tailings; chemical properties; microbial biomass; enzyme activities

## 07 Growth Stress and Photosynthetic Characteristics of *Vetiveria zizanioides* by Direct Landfill and the Content Dilution of Used Batteries

LIU Jinxiang, MO Xuemei, ZHU Yanfeng, GUO Longwu

(Tropical Institute of Grassland Science, Zhanjiang Normal University, Zhanjiang, Guangdong 524048, China)

**Abstract** The influence on the cell membrane, proline content (Pro), chlorophyll content (Chl), photosynthetic rate (Pn), transpiration rate (Tr) and stomatal conductance (Gs) of *Vetiveria zizanioides* from two different used batteries stress treatments were studied by pot experiment. The results showed that as the amount of direct landfill and the concentration of content dilution of used batteries increased, the leaf growth rate, Chl content, Pn, Tr and Gs of *V. zizanioides* declined, and Pro content, membrane permeability increased. There was no significant difference

effects on the stress of *V. zizanioides* between direct landfill and the contents dilution of the used batteries. When the diluted solution was 14.44% or less of the soil and the landfilled amount was 2.70% or less of the soil, *V. zizanioides* could grow, while that was 20.20% or more, 4.00% or more, respectively, *V. zizanioides* would die.

**Key words** *Vetiveria zizanioides*; Used batteries; Dandfill; Dilution

doi 10.3969/j.issn.1000-2561.2011.07.011

## 08 *Vetiveria Zizanioides* Adaptability of Lead-zinc Mine Tailings on the Growth

Gao Xi<sup>1</sup>, Zhang Pei<sup>2</sup>, Cao Jianhua<sup>3</sup>

(1.The 1st Team of Nonferrous Metal Geological of Bureau of Geology and Mineral Resources of Henan, Zhengzhou 450016, China; 2.Hydrology and Water Resources Centre Survey Bureau in Zhumadian, Zhumadian 463000, China; 3.Key Laboratory of Karst Dynamics, Ministry of Land and Resources, Karst Geology Institute of Chinese Academy of Geoscience, Guilin 541004, China)

**Abstract:** The paper studies the NPK fertilizer and humus (*corrupted platycodon grandiflorum*) affect on growth of *vetiveria zizanioides* in lead-zinc mine tailings though a pot experiment. The results show that *vetiveria zizanioides* growing on the mine tailings which are added the NPK fertilizer and humus, have the higher index than the *vetiveria zizanioides* both on pure tailings and on the mine tailings only added the NPK fertilizer, and these index include biomass, morphological traits, resistance index, photosynthetic rate, transpiration rate, stomatal conductance and water use efficiency other indicators. Studies have shown that the integrated utilization of NPK fertilizer and humus can increase *vetiveria zizanioides* adaptability of Lead-zinc mine tailings.

**Keywords:** pot experiment; mine tailings; *vetiveria zizanioides*; adaptability