Phytomining gold: soil trials

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ABSTRACT

The use of plants for precious metals recovery could be a suitable and sustainable alternative to current mining and remediation technologies. Field experiments have shown that certain plants have the capability of hyperaccumulating gold, which can be improved using metal chelators. The introduction of new chelators to enhance plant metal uptake ability is a promising approach for gold recovery. In this work greenhouse experiments were performed to test the chelating agents ammonium tiocyanate (NH_4SCN) and thiourea (TU) as gold-uptake enhancers. Seeds of *Chilopsis linearis* were sown in pots containing sandy soil spiked with gold solution at concentrations of 5 and 10 mg Au kg^{-1} soil. Separate solutions of NH_4SCN and thiourea at 100 µM were added to the pots after 1 month of plant growth. The above ground plant parts were harvested after different periods of time to assess the plant-metal-uptake response. Stems and leaves were separated, oven dried for 72 h, microwave acid digested, and the gold content was determined using ICP/OES. Results indicate that *C. linearis* is a gold hyperaccumulator. Moreover, leaves of plant exposed to 5 mg of Au kg-1 presented an increase of about 50% in Au concentration 24 h after TU application. However, the leaves of plants exposed to 10 mg Au kg-1 presented an increase of about 175% in Au concentration 5 h after TU application. These results suggest that thiourea could improve the Au uptake capacity of *C. linearis*.

INTRODUCTION

I. Phytomining

- Plants are used to recover valuable metals from soil
- Phytomining is a new alternative for gold-reclamation
- Advantages of phytomining include: phytostabilization of acid mine tailings, erosion control, leaching prevention, and soil recovery.

Berkheya coddii is being cropped for nickel. Harvested biomass is fed into the metal smelter

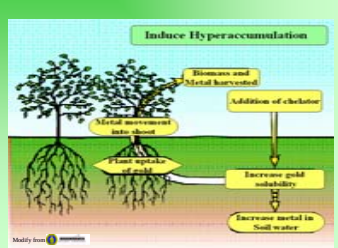
Environmental degraded areas due to mine tailing deposits

Growing *Chilopsis linearis* to absorb gold

Harvesting and incineration to recover the metal

II. Chelators favor metal absorption

- Plants exudate chelators to improve nutrient absorption
- Gold absorption could be enhanced using synthetic chelators like ammonium thiocyanate and thiourea, which form water soluble complex with gold.



OBJECTIVE

To determine the effect of the Au chelators ammonium thiocyanate (NH_4SCN) and thiourea (TU) on gold absorption by the desert plant *Chilopsis linearis* (Desert willow) grown in soil.

METHODOLOGY

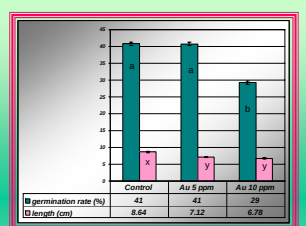
Soil collection | Soil preparation and seed sowing | Seed germination | Plants grown for one month | Treatment application | Plant harvesting and size determination | Metal determination In plant samples

- Soil and seeds were collected from a non contaminated area around El Paso
- The soil was sterilized, spiked with gold at 5 and 10 ppm, characterized and weighted. (1kg per plastic black bags). 200 ml of nutrient solution were pour into each pot and 30 seeds were sown
- After seed germination, the seedlings were allowed to grow for 1 month before the application of the treatments.
- Each pot was wetted with tap water to kept it at 60% of their water hold capacity (WHC)
- Treatments were applied by pouring 100 ml of the corresponding solution to each pot (Table 1). 5 pots per treatment were set up.
- Plants were harvested after 5, 24, 48 and 96 h after the treatment application. They were measured and separated in stems, and leaves; dried at 60°C for 48 h in an oven and microwave digested using 5ml of concentrated HNO_3
- Au concentration in plant tissues was quantified using the EPA method 200.7 [inductively coupled plasma-atomic emission spectrometry (ICP-AES)]

Soil \ Leaching Solution	Nutrient Solution (NS)	NS + NH_4SCN 100 µM	NS + Thiourea 100 µM
Control	√	√	√
Spiked with 5 ppm of Au	√	√	√
Spiked with 10 ppm of Au	√	√	√

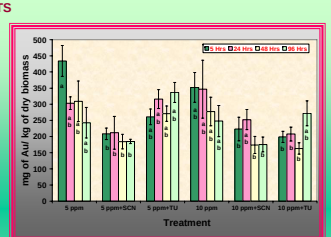
Table 1. Treatments

RESULTS



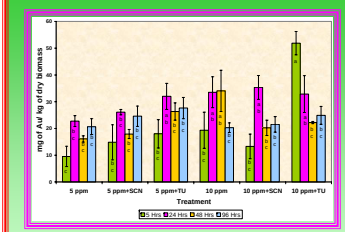
Effect of gold concentration on germination rate and growth of *C. linearis*

- The seed germination decreased about 25% (P<0.05) when planted in soil spiked with gold at 10 ppm but not at 5 ppm.
- Shoot elongation was reduced by about 19% (P<0.05) when gold was present in the growth medium in both treatments



Effect of SCN and TU on gold accumulation in stems of *C. linearis* plants grown in soil spiked with Au at 5 and 10 ppm

- The average Au content was about 260 mg Au kg^{-1} dry wt (DW), which is higher to the reported when *C. linearis* was grown in hydroponics medium (70 mg Au kg^{-1} DW) [Gardea-Torresdey et al., Anal Bioanal Chem 382(2), 347-352. 2005]
- None of the treatments produced statistical differences in Au accumulation (P<0.05).



Effect of SCN and TU on gold accumulation in leaves of *C. linearis* plants grown in soil spiked with Au at 5 and 10 ppm

- The average gold content in leaves was 26 mg Au kg^{-1} DW, 26 times larger than the criterion for Au hyperaccumulation (1 mg kg^{-1} DW).
- The use of chelators increased the Au concentration in leaves in plants grown with Au at 5 mg kg^{-1}. But the increase was not statistically larger.
- There were not significant differences in Au content in leaves harvested at different time intervals.

CONCLUSIONS

- The data *from soil experiments* has shown that *C. linearis* could be a potential gold hyperaccumulator.
- Both germination rate and plant elongation were affected by gold in the soil media.
- Neither SCN nor thiourea showed a significant effect in the gold accumulation in stems; however, it seems that the use of chelators increase the Au translocation from root to leaves in plants grown with Au at 5 mg per kg of soil. Nevertheless, further studies are needed using larger concentrations of chelators to have concluding results.
- The data suggested that the amount of gold in solution is not the major factor controlling gold absorption and translocation from root to shoot in *C. linearis*.

Further Experiments

- Use of chelating agents at larger concentrations.
- Study of Au distribution in roots, stems, and leaves at cellular level using STEM (scanning transmission electron microscopy)

Acknowledgments

- The University of Texas at El Paso (UTEP), USA
- Texas A & M Agricultural Experiment Station, El Paso, Tx
- National Council of Science and Technology (CONACyT), Mexico
- University of Guanajuato, Mexico
- Center for Environmental Resource Management (CERM), USA
- National Institutes of Health (NIH/SCORE), USA
- (HBCU/MI ETC DOE)
- Dudley Family for Dr. Gardea Endowed Chair