RESEARCH PAPER:

Effect of mine spoils on soil and plant enzyme activity of rhizosphere soil

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Asian Journal of Environmental Science (December, 2009 to May, 2010) Vol. 4 No. 2 : 139-141

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SUMMARY

A pot culture experiment was conducted in the Department of Environmental Science, Tamil Nadu Agricultural University, Coimbatore to evaluate the role of enzyme activities in metal accumulation in magnesite and coal mine spoils. The activities of soil enzymes like phosphatase, dehydrogenase, amylase, plant peroxidases and plant catalases considerably increased in red soil compared to magnesite and coal mine spoils. The soil and plant enzyme activities were found to be higher in *Amaranthus* sp. grown in red soil (T1) compared to mine spoils. The activities of enzymes in soil and plant increased over time and 45th day sample recorded the highest activity of enzyme, after which it got reduced. The results indicated that enzyme activities of mine spoils decreased in the rhizosphere soil due to the low availability of nutrients in mine spoils compared to red soil.

Key words :
Mine spoils, *Amaranthus* sp., *Brassica* sp., Enzyme activity

Accepted :
August, 2009

Mining is an anthropogenic activity that changes the soil profile, physical, chemical and biological properties. Soil disturbance caused by mining leads to loss of aggregation, decline in soil organic carbon, loss of soil structure, increased bulk density and reduced porosity (Shukla *et al*., 2003). Phytotransformation refers to the uptake of contaminants from soil and ground water and the subsequent metabolism or transformation by plants. Detoxification mechanisms may transform the parent chemical to nonphytotoxic metabolites stored in plant tissues. A thorough understanding of pathways and end products of enzymatic process will simplify toxicity investigation of *in situ* phytoremediation. Saxena *et al*. (1999) indicated that metals like mercury, selenium, argenic or chromium can be rendered harmless by either enzymatic reduction or by incorporation into toxic organic / metal compounds. These processes occur in nature and can be enhanced by genetic manipulation of plants through introduction of genes coding for enzymes responsible for the underlying biochemical reactions. Some plant ecotypes endemic to heavy metal polluted soils have been shown to contain heavy metal resistant enzyme for example, cell wall acid phosphatase. However, it is unlikely that the development of heavymetal resistant biochemical processes could be a viable heavymetal resistant mechanism (Salt *et al*., 1995).

MATERIALS AND METHODS

A pot culture experiment was conducted to evaluate the role of enzyme activities in metal accumulation in magnesite and coal mine spoils. The experiment was conducted in the Department of Environmental Science, Tamil Nadu Agricultural University, Coimbatore.

Treatment details:

T_1 -Red soil + *Amaranthus* sp., T_2-Red soil + *Brassica* sp., T_3 - Coal mine spoil + *Amaranthus* sp., T_4 - Coal mine spoil + *Brassica* sp., T_5 - Magnesite mine spoil + *Amaranthus* sp., T_6 - Magnesite mine spoil + *Brassica* sp.,

Replication : 3

Design : Factorial Completely Randomized Block Design (FCRD)

The soil and plant samples collected from the pot culture experiment at post germination (five and four days for *Amaranthus* and *Brassica* species, respectively), 45th day and post harvest stage were used for analyzing the enzyme activities. The soil phosphatase, dehydrogenase and amylase enzyme activities were analyzed in soil samples and peroxidase and catalase enzyme activities were analyzed in plant samples. The analysis for the soil and plant enzymes of the mine spoil samples were carried out as per the procedure given as below.

Enzymes	Method	References
Soil enzymes		
1. Phosphatase	p-nitrophenol phosphate method	Tabatabai and Bremner, 1969.
2. Dehydrogenase	2,3,5-Triphenyl Tetrazolium chloride method	Chendrayan *et al.*, 1980
3. Amylase	Acetate buffer method	Ross, 1966.
Plant enzymes		
1. Peroxidase	Colorimeter method	Peru, 1962.
2. Catalase	Hydrogen peroxide	Gopalachari, 1963.

RESULTS AND DISCUSSION

The soil phosphatase, dehydrogenase and amylase activities were significantly influenced by the treatments (Table 1). The phosphatase, dehydrogenase and amylase activities were found to be high in *Amaranthus* sp. grown in red soil (20 µg of PNP-P g^{-1}, 16 µg of TPF g^{-1} and 800 mg of glucose g^{-1}, respectively) compared to *Brassica* sp. grown in coal mine spoil (10 µg of PNP-P g^{-1}, 9 µg of TPF g^{-1} and 433 mg of glucose g^{-1}, respectively). The plant enzyme activities *viz.*, peroxidase and catalase also significantly differered with treatments (Table 2). *Amaranthus* sp. grown in red soil recorded the highest enzyme activity of 15 g^{-1} m^{-1} and 46 µmol H_2O_2 g^{-1} h^{-1}, respectively. The lowest plant peroxidase and catalase activities were recorded in *Brassica* sp. grown in coal

Table 1 : Effect of mine spoils on soil enzyme activities of rhizosphere soil in different plant species

Treatments	Enzyme activities											
	Phosphatase activity (µg of PNPP g^{-1})				Dehydrogenase activity (µg of TPF g^{-1})				Amylase activity (mg of glucose g^{-1})			
	Post germination	45th day	Post harvest	Mean	Post germination	45th day	Post harvest	Mean	Post germination	45th day	Post harvest	Mean
T_1	16	24	20	20	12	19	16	16	774	824	803	800
T_2	17	21	17	18	10	15	14	13	802	813	782	799
T_3	9	14	12	12	7	11	9	9	437	483	463	461
T_4	7	12	10	10	7	10	10	9	409	462	428	433
T_5	12	17	13	14	10	14	12	12	527	595	541	554
T_6	10	15	11	12	9	13	10	11	496	547	521	521
Mean	12	17	14	14	9.2	13.7	11.8	11.6	574	621	590	595
	S.E.±		C.D. (P=0.05)		S.E.±		C.D. (P=0.05)		S.E.±		C.D. (P=0.05)	
T	0.4757		0.9649		0.2885		0.5851		39.3539		79.8223	
D	0.3364		0.6823		0.2040		0.4137		27.8274		56.4429	
T x D	0.8239		1.6712		0.4996		1.0134		68.1629		138.2563	

Table 2 : Effect of mine spoils on plant enzyme activities of different plant species

Treatments	Enzyme activities							
	Catalase activity (µmol H_2O_2 g^{-1} h^{-1})				Peroxidase activity (g^{-1} m^{-1})			
	Post germination	45th Day	Post harvest	Mean	Post hermination	45th Day	Post harvest	Mean
T_1	41	59	39	46	11	19	15	15
T_2	37	55	34	42	12	17	13	14
T_3	22	32	24	26	7	12	12	10
T_4	19	24	16	20	7	10	8	8
T_5	27	36	30	31	10	14	13	12
T_6	25	33	26	28	9	11	8	9
Mean	29	40	28	32	9.3	13.7	11.3	11.4
	S.E.±		C.D. (P=0.05)		S.E.±		C.D. (P=0.05)	
T	1.7177		3.4841		0.2940		0.5963	
D	1.2146		2.4636		0.2079		0.4216	
T x D	2.9752		6.0347		0.5092		1.0328	

mine spoil (8 g^{-1} m^{-1} and 20 µmol H_2O_2 g^{-1} h^{-1}, respectively). The enzyme activities were higher in red soil compared to mine spoil, which may probably be due to the better availability of nutrients, increased microbial activity of soil and growth of plant species. Garcia *et al*. (1993) reported that the amylase activity was higher in the soil due to the high level of nutrient availability. The activity of enzyme in soil was significantly increased over sampling period and the 45th day sample recorded maximum soil phosphatase, soil dehydrogenase, soil amylase, plant peroxidase and plant catalase activities of 17 µg of PNP-P g^{-1}, 13.7 µg of TPF g^{-1}, 621 mg of glucose g^{-1}, 13.7 g^{-1} m^{-1} and 40 µmol H_2O_2 g^{-1} h^{-1}, respectively. Activity of enzyme in soil and plant was recorded to be lower in post harvest stage. Increased activity of enzyme over sampling periods might be due to increased microbial activity which would have enhanced the organic matter degradation and mineralization. Rajannan *et al*. (1998) reported that catalase and dehydrogenase were considered as important enzymes for oxidative process in the soil. Decrease in enzymatic activities at post harvest stage could be due to the reduction of nutrient contents as a result of plant utilization. This is in accordance with the findings of Pallab De *et al*. (1990) who reported that enzyme activities depend on the type and physiological stage of standing crop.

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