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Influence of Various Concentrations of Cadmium on Soil Dehydrogenase Enzyme Activity and Soil Respiration

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The effects of different concentrations of Cd (100, 200, 400, 800 and 1600 ppm) on the activity of soil dehydrogenase enzyme and soil respiration were studied after 15 days and 30 days of incubation period. The maximum activity of soil dehydrogenase enzyme was observed at 100 ppm dose of Cd after 15 days of incubation period. Beyond this level a gradual reduction in enzymatic activity was observed. After 30 days of incubation period, all the applied doses of Cd resulted in a marked reduction in the activity of dehydrogenase enzyme, over the control. After 30 days of incubation period a negative correlation was observed between soil dehydrogenase enzyme activity and soil applied doses of Cd. After 15 days of incubation period, no significant difference was observed in soil respiration. Soil respiration was significantly inhibited in all applied doses of Cd after 30 days of incubation period. Soil dehydrogenase enzyme activity and soil respiration can be used as indicators for cadmium toxicity in soils.

Key words: Cadmium, Soil Dehydrogenase Enzyme, Soil Respiration.

Cadmium (Cd) is a potentially hazardous pollutant and ubiquitous in the environment and has been recognized as one of the most deleterious heavy metal pollutant (Roards and Worsfold, 1991). Cd has most adverse affects on microbial biomass. Its activity play an important role in the biological cycling, soil nutrient cycling and in maintaining soil fertility (Jose *et al*., 2002; Yao *et al*., 2003). Studies of enzyme activities in soil are important as they indicate that the activity of soil enzymes support biochemical processes which are essential for the maintenance of soil fertility. Enzymatic activity of soil is a reliable measure of current biological status. Dehydrogenase activity in soils provides correlative information on the biological activity and microbial populations in the soil.

Soil respiration intensity is a measure of the background microbial respiration and it is commonly regarded as the overall decomposition of the organic material (Stenberg, 1999). Sastre Conde *et al*. (2003) and Krushelnickaja (2001) observed that the soil biological activity is one of the most representative indicators of soil pollution. Therefore, a pot trial was undertaken to study the effects of various concentrations of Cd on soil dehydrogenase enzyme activity and soil respiration.

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MATERIAL AND METHODS

Experimental soil was a sandy soil with a pH 8.2, moisture 1.66%, and water holding capacity (WHC) 34.95 %, Bulk desity 1.43 g / cc, Specific gravity 4.06, porosity 64.78 % and organic carbon 0.315 % (Table 1).

Different concentrations of cadmium as cadmium chloride were prepared separately by taking corresponding amounts (calculated on the basis of molecular weight) of the chemical per kilogram of soil sample. Cadmium chloride was applied at doses of 100, 200, 400, 800 and 1600 ppm Cd of soil. Pots without the added Cd constituted the control. Experiment was set during the month of May. Three replicates were prepared of each concentration and its moisture content was brought up to 60% water holding capacity by pouring distilled water. This moisture content was maintained throughout the whole experiment.

Activities of soil enzymes were measured after 15 days and 30 days of incubation period. The soil dehydrogenase enzyme activity was determined by Casida *et al.* (1964). The substrate of dehydrogenase enzyme was 3% aqueous TTC (2, 3, 5 Tri phenyl Tetrzolium Chloride) solution. Soil incubation was carried out for 24 hrs at 30°C and activity was measured at a wavelength of 485nm with the help of a spectrophotometer. The activity was expressed as µg TPF g^{-1} soil 24 h^{-1}.

Table 1. Physico-chemical parameters of experimental soil.

S.No.	Physico-chemical parameters	Soil
1.	Soil pH	8.2
2.	Soil moisture%	1.66
3.	Soil texture	
	Coarse gravel (%)	20
	Gravel (%)	10
	Coarse sand (%)	22
	Fine sand (%)	28
	Slit (%)	18
	Clay (%)	02
4.	WHC (%)	34.95
5.	Bulk density (g/cc)	1.43
6.	Specific gravity	4.06
7.	Porosity (%)	64.78
8.	Organic carbon (%)	0.315

Soil respiration was determined by measuring CO_2 evolution from soil by method of Pramer and Schmidt (1964) with slight modification.

RESULTS AND DISCUSSION

Heavy metal pollution affects the growth, morphology and metabolism of microorganisms in soil through functional disturbance, protein denaturation or the destruction of the cell membranes.

Wilke (1991) observed that dehydrogenase activity is very sensitive to heavy metals and can be used as a simple toxicity test. Dehydrogenase activity negatively correlated with soil applied concentrations of cadmium (Fig. 1). Soil contamination with cadmium had a strong antagonistic effect on the activity of soil enzymes. Murata *et al.* (2005) observed that the contamination of soil dehydrogenase activity is a useful tool for assessing the potential impact of heavy metal contamination in soil, even for short time incubation studies. Brookes *et al.* (1984) reported less dehydrogenase activity in metal contaminated soil than in similar uncontaminated soil while soil phosphatase was unaffected. Bitton *et al.* (1986) have shown that 1.8 ppm Cd inhibited the dehydrogenase activity of 50% of the bacterial population.

Olszowska (1998) reported that soil contamination with cadmium can depress the activity of dehydrogenases enzymes by up to 80-95% relative to the control. In the present study addition of higher doses of Cd (200- 1600 ppm) resulted in an enhancement in enzymatic activity at both the incubation periods (15 & 30 days of incubation period) (Fig. 1).

Wyszkowska and Wyszkowski (2006) observed that soil contamination with cadmium depressed the activity of dehydrogenase, urease, alkaline phosphatase and less strongly acid phosphatase. Dar (1996) observed significant negative correlation between the concentration of cadmium in soil and activity of dehydrogenases and phosphatase.

In the present study, the maxium soil dehydrogenase activity was observed at 100 ppm concentration of cadmium after 15 days of incubation period. Beyond this level a gradual contaminated soils than in soils near the source of contamination, but the difference was not significant. A negative correlation was observed between Cd concentrations and soil respiration after 30 days of incubation period.

REFERENCES

1. Bitton, G., Khafif, T., Chataigner, N., Bastide, J., Coste, C. M. A direct INT- dehydrogenase assay for assessing chemical toxicity assessment. 1986; **1**:1-12.
2. Bond, H., Lightart, B., Shimabuku, R., Russel, L. Some effects of Cd on coniferous forest soil and litter microcosm. *Soil Sci*. 1976; **121**: 278- 287.
3. Brookes, P.C., McGrath, S.P. Effect of metal toxicity on the size of microbial biomass. *Journal of Soil Science*, 1984; **35**:341-346.
4. Casida, L.E.Jr., Klein, D.A., Santoro, R. Soil dehydrogenase activity. *Soil Science*, 1964; **98**: 371- 378.
5. Chaney, W. R., Kelly, J. M., Strickland, R. C. Influence of Cd and Zn on carbon dioxide evolution from litter and soil from a black forest. *J. Environ. Qual*. 1978; **7**: 115- 119.
6. Dar, G.H. Effects of cadmium and sewage-sludge on soil microbial biomass and enzyme activities. *Biores. Tech.,* 1996; **56** (2-3): 141.
7. Doelman, P., Haanstra, L. Short- term and long-term effects of Cd, Cr, Cu, Ni, Pb and Zn on microbial respiration in relation to abiotic soil factors. *Plant and Soil*. 1984; **79**: 317-321.
8. Jose, L.M., Teresa, H., Aurelia, P., Carlos, G. Toxicity of Cd to soil microbial activity: Effect of sewage sludge addition to soil on the ecological dose. *Applied Soil Ecology*, 2002; **21**: 149- 158.
9. Krushelnickaja, T. P. The changes of enzyme activities in sod- gleyic soil under anthropogenic influence. Soils and their fertility on border of centuries. IIth Congress of Belorussian Soil science Society, Minsk, Book 2, 2001; 148- 150.
10. Kubat, J., Novakova, J., Mikanova, O., Simon, T. Selection of microbial methods for the bioinduction of soil pollution. Pathways and consequences of the dissemination of pollutants in the biosphere II. Symp, Praha, 1999; 61- 75.
11. Motuzas, A., Vaisvalavicius, R., Zakarauskite, D., Grigaliuniene, K., Butkus, V. Experimental studies on soil enzymes changes under the critical heavy metals accumulation in luvisols and albeluvisols. *Latvian Journal of Agrnomy,* 2005; **8**: 65- 70.
12. Murata, T., Koshikawa, M. K., Takamatsu, T. Effects of Cu, Sb, In and Ag contamination on the proliferation of soil bacterial colonies, soil dehydrogenase activity and phospholipid fatty acid profiles of soil microbial communities. *Water, Air and Soil Pollution*. 2005; **164**: 103- 118.
13. Olszowska, G. Effect of cadmium- zinc dusts on the activity of various soil enzymes. *Pr. Inst. Bad. Lesn.,* 1998; 847: 111.
14. Pramer. D., Schmidt E. L. Experiment soil microbiology, Burgess, Minneapolis, Minnesota. 1964; 6-13.
15. Renella, G., Chaudri, A.M., Brookes, P.C.. Fresh additions of heavy metals do not model long-term effects on microbial biomass and activity. *Soil Biology and Biochemistry,* 2002; **34** (1): 121-124.
16. Robards, K., Worsfold, P. Cd: Toxicology and analysis. *A review analyst,* 1991; **116**: 549- 568.
17. Sastre conde, I., Vicente, M. A., Lobo, M. C. Contamination and environmental impact on soil biological activity. In: Lobo M. C., Ibanez J. J. (eds) Preseving soil quality and soil biodiversity, IMIA- CSIC, Madrid. Italy, 2003; 99- 118.
18. Smejkalova, M., Mikanova, O., Boruvka, L. Effects of heavy metal concentrations on biological activity of soil micro-organisms. *Plant soil environment*, 2003; **49** (7): 321-326.
19. Stenberg, B. Monitoring of soil quality of arable land: Microbiological indicators. *Soil and plant science,* 1999; **49**: Nr.1, 1-21.
20. Tesarova, M. Kvalita pud a jeji biologicke parametry. In: Pedologicke dny 2000. Kostelec nad Cernymi lesy, 2000; 85- 91.
21. Welp, G. Inhibitory effects of the total water-soluble concentrations of nine different metals on the dehydrogenase activity of a loess soil. 1999; **30**(1-2):132.
22. Wilke, B.M. Effects of Single and Successive Additions of Cd, Ni and Zn on Carbon Dioxide Evolution and Dehydrogenase Activity in a Sandy Luvisol. *Biol. Fertil. Soils*, 1991; **11**: 34-37.
23. Wyszkowska, J., Zaborowska, M., Kucharski, J. Activity of enzymes in zinc contaminated soil. *Electronic journal of polish Agricultural Universities*, 2006; **9**: 1.
24. Yao, H.Y., Xu, J.M., Huang, C.Y. Substrate utilization pattern, biomass and activity of microbial communities in a sequence of heavy metal- polluted paddy soils. *Geoderma,* 2003; **115**: 139-148.