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Effect of Heavy Metal on Soil Respiration

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Abstract:

Gopalpur soil was taken to understand the effect of heavy metals on soil respiration. Solutions of analytical grade sulphate (SO_4) salt each of zinc, copper and cadmium was applied singly and in combinations. Soil sample which receives no metal amendment was served as control. Control, Cu (3000 ppm), Cd (3000 ppm), Zn (3000 ppm), Cu:Cd (1500 ppm:1500 ppm), Cd:Zn (1500 ppm:1500 ppm), Cu:Zn (1500 ppm:1500 ppm), and Cu:Cd:Zn (1000 ppm:1000 ppm :1000 ppm) were the treatments of this experiment. All treatments were replicated three times. 0 day, 14 days, 30 days, 45 days and 60 days were selected as incubation periods. Zn (3000 ppm) showed higher decreasing rate of respiration. Decrease rate of respiration was in minimum for Cu and Cd combination where maximum decrease rate was observed in Cu and Zn pair.

Keywords: Gopalpur soil, heavy metal, soil respiration, incubation, treatments

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Introduction

Soil is a complex mixture of minerals, nutrients, organic matter and living organisms upon which all other terrestrial tropic systems are dependent [1]. It is a vital resource for sustaining basic human needs such as food, fiber and shelter. It serves as the key supplier of heavy metals to the hydrosphere, atmosphere and living organisms, and therefore plays a crucial role in cycling of metals in nature. Metals released from various sources may finally reach the top soil, and their further fate depends on soil physical and chemical properties such as pH, redox potential, organic C, clay content and cation exchange capacity [2]. Once the metals enter in soil, they are strongly held by soil particles and there is little removal by plant uptake or movement down the soil profile. In low and medium contaminated soils, concentration of metals in crops is mostly not high enough to cause acute toxicity, but in the long run, it may cause chronic damage to human animal health [3]. Soil microorganisms are regarded as a sensitive indicator of the changes occurring in soil ecosystem. Microbial parameters used to quantify soil biological activity include soil microbial biomass C, soil respiration and organic carbon. Pollution effects on soil microbes are fundamentally related to the effects on crop plants, natural vegetation and ecosystem productivity. Studies on heavy metals pollution of soils have shown decline in soil productivity through perturbation of microbial processes in soils by long term exposure of heavy metals [4]. Heavy metals come from a variety of sources but principally from anthropogenic activities such as chemical manufacturing, electic power generation, coal and ore mining. Some of the metals such as copper, cadmium and zinc are essential in very low concentrations serving as components of enzymes, structural proteins, pigments and in maintaining the ionic balance of cells. For eco-toxicological research to be capable of influencing policies and regulations pertaining to environmental sustainability and conservation it must be methodologically planned and ecosystem oriented [5]. The contamination of soils by heavy metals is significant problem, which leads to negative influence on soil characteristics and limitation of productive and environmental functions. The soil microbial community has a fundamental role in the process of organic matter degradation and mineralization, which allows the recycling of nutrients [6]. Soil respiration, measured as CO_2 evolution or O_2 consumption, is one of the easiest, most general and most frequently used parameters for measuring the decomposition of organic compounds in soil. It depends on many biotic and abiotic factors, which prevents comparison of the degree of soil microflora functioning on its respiration level. Therefore, the effect of heavy metals on organic carbon, microbial biomass carbon and soil respiration in various soils may only be assessed based on the principle of proportional change in activity in comparison with the control. The rate of soil respiration (CO_2 evolution) decreased with increasing heavy metals concentration. The bioavailability of Cd, Cu and Zn and associated toxicity to soil biota vary with time, soil type, speciation, ageing, Cd, Cu and Zn sources, organisms, and the environmental factors [7]. The main objective of this study was to measure the effect of heavy metal (Cu, Cd and Zn) on soil respiration.

Materials and Methods

Location and extent

Soil sample was collected from 5-15 cm depth in composite manner. The general description of the location is discussed in Table 1.

Table (1) General description of the location.

Sample No.	GPS Reading	Address	Physiography	Soil Series
1	N: 22º 55.040´ E: 89º 31.704´	Village: Barakpur Union: Barakpur Thana: Dighalia District: Khulna	Ganges meander floodplain	Gopalpur

Processing of Soil Samples

Surface soil was collected from field. The soil was taken in laboratory using thermo flask. The sample was sieved (mesh size < 2 mm), sorted to remove stones, plant debris any visible sieved soil fauna and then it was mixed thoroughly with hand trowel. Some physical and chemical properties of initial soil sample were determined. Those properties are presented in Table 2. One kg of the sieved soil sample was taken in each of the plastic pots. Solutions of analytical grade Sulphate (SO_4) salts each of zinc, copper and cadmium were applied to the respective pots singly and in combinations. Soil sample, which received no metal amendment, was served as control. Proper labeling was done by using treatment code.

Table (2) some physical and chemical properties of initial soil sample.

Soil properties	Value
Textural class	Silty Loam
Soil pH	6.5
Soil moisture (%)	28.78
Field capacity (%)	52.75
EC (dS/m)	2.52
Ca	368 (ppm)
Mg	40.57 (ppm)
Zn	4.409 (ppm)
Cd	0.036 (ppm)
Cu	1.22 (ppm)
Pb	0 (ppm)

Experimental design

The experiment was laid out in a Complete Randomize Design (CRD) with three replications. The codes of the treatment are shown in Table 3. For this experiment, the incubation periods were 0 day, 14 days, 30 days, 45 days and 60 days.

Table (3) Treatments code.

Code	Heavy metal	Concentration (ppm)
0	Control	0
A	Cu	3000
B	Cd	3000
C	Zn	3000
D	Cu:Cd	(1500:1500)
E	Cd:Zn	(1500:1500)
F	Zn:Cu	(1500:1500)
G	Cu:Cd:Zn	(1000:1000:1000)

Respiration

Soil respiration was determined as discussed by Anderson and Ingram, 1996 [8]. From the freeze the soil sample was weighted and was left for 24 hours in a desiccators along with 5ml 0.1M NaOH exposed in a 100 ml beaker for 24 hours followed by tritration with standardized 0.1M HCl. Absorbed CO_2 is calculated according to formula given by Stotzky, 1965 [9].

Milligrams of C or CO_2= (B-V)NE

B=Volume of acid needed to titrate the NaOH (ml)

V=Volume of acid nedded to titrate the NaOH (ml) exposed to soil

N=Normality of acid

E=Equivalent weight of C or CO_2

Statistical analysis

The collected data on different parameters were analyzed following analysis of variance (ANOVA) technique by using MINITAB program.

Results and Discussion

Changes of respiration after adding of copper (Cu) in soils:

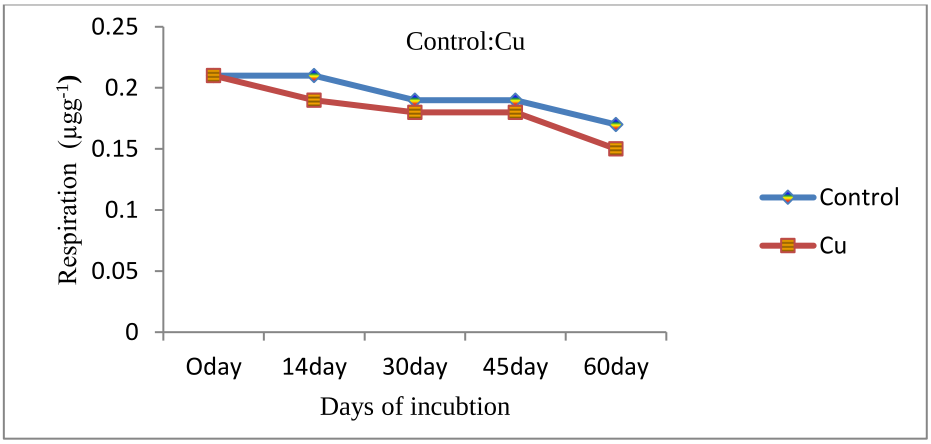

Figure 1. Changes of respiration in soil due to application of Cu

Figure 1**.** shows significant ($p \leq 0.05$) changes in respiration due to the application of Cu (3000 $mgkg^{-1}$) as well as with the days of incubation. The lowest value (0.15 μgg^{-1}) of the respiration was found at 60 days. The respiration decreased significantly in the incubation due to the antagonistic effect of copper in the mineralization of carbon in soil. Mellor, 1904 [10] found a result similar to this.

Changes of respiration after adding of cadmium (Cd) in soils:

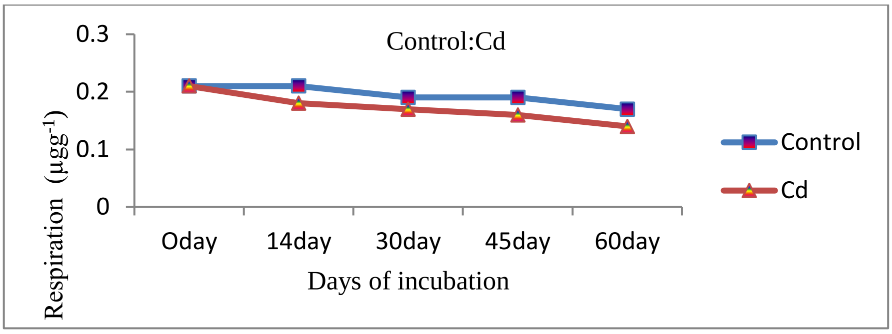

Figure .2. Changes of respiration in soil due to application of Cd

Figure 2. shows significant (p≤0.01) changes in respiration due to the application of Cd (3000 $mgkg^{-1}$) as well as with the days of incubation**.** The lowest value (0.14 μgg^{-1}) was found at 60 days. This finding is consistent with those reported by Chaney *et al.*, 1978 [11] and Adriano (1986) [12].

Changes of respiration after adding of zinc (Zn) in soils:

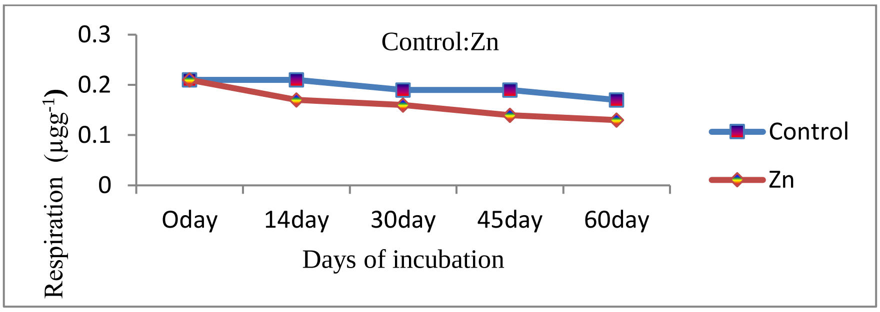

Figure 3. Changes of respiration in soil due to application of Zn

Figure 3 shows significant (p≤0.01) changes in respiration due to the application of Zn (3000 $mgkg^{-1}$) as well as with the days of incubation. The lowest value (0.13 μgg^{-1}) was found at 60 days. Inhibition of residue respiration by heavy metals was reported previously and it reflected the harmful effect of zinc on residue decomposer communities [13].

Changes of respiration after adding of (Cu:Cd) in soils:

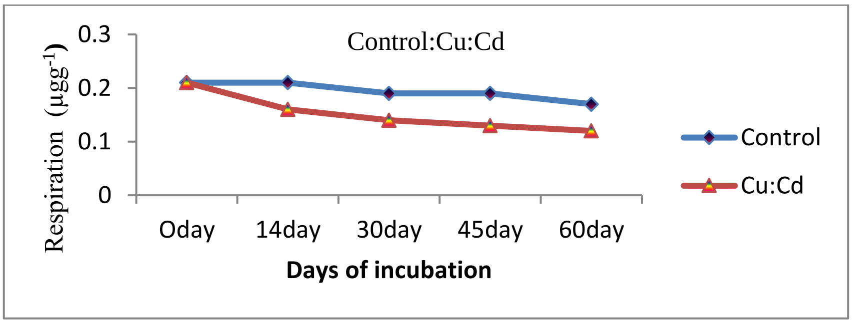

Figure 4. Changes of respiration in soil due to application of (Cu:Cd)

Figure 4 shows significant (p≤0.01) changes in respiration due to the application of (Cu:Cd) as well as with the days of incubation. The respiration decreased with increasing the concentration of (Cu:Cd) in incubation due to the antagonistic effect of Cu in the mineralization of carbon in soil. The result of this present investigation is in agreement with the study of Beare *et al.*, 1993 [14].

Changes of respiration after adding of (Cd:Zn) in soils:

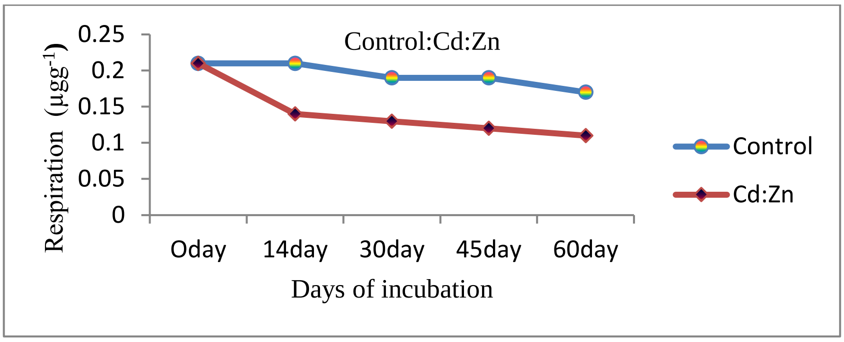

Figure 5. Changes of respiration in soil due to application of (Cd:Zn)

Figure 5 shows significant ($p \leq 0.01$) changes in respiration due to the application of (Cd:Zn) as well as with the days of incubation. The respiration decreased with increasing the concentration of (Cu:Cd) in incubation due to the antagonistic effect of Cu inthe mineralization of carbon in soil. According to Brook, 1995 [15], high levels of artificially added Cd and Zn may cause to decrease the respiration rate.

Changes of respiration after adding of (Cu:Zn) in soils:.

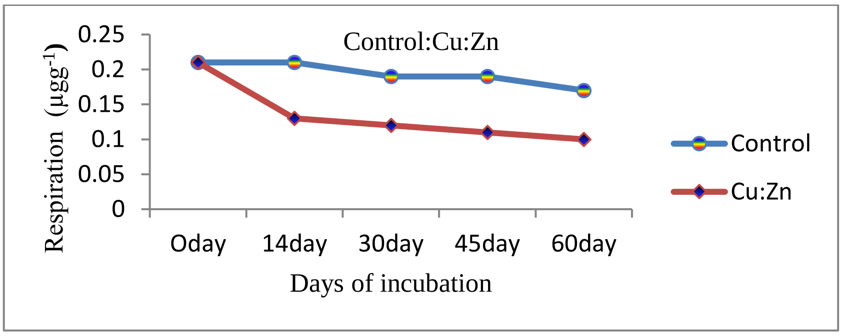

Figure 6. Changes of respiration in soil due to application of (Cu:Zn)

Figure 6 shows significant ($p \leq 0.01$) changes in respiration due to the application of (Cu:Zn) as well as with the days of incubation. The respiration decreased with increasing the concentration of (Cu:Cd) in incubation due to the antagonistic effect of Cu in the mineralization of carbon in soil. The lowest value (0.11 μgg^{-1}) was found at 60 days. It is believed that that an additive action and synergistic effect between Cu and Zn could have been responsible for the enhanced toxicity of Cu:Zn in the soil sample [16].

Changes of respiration after adding of (Cu:Cd:Zn) in soils:

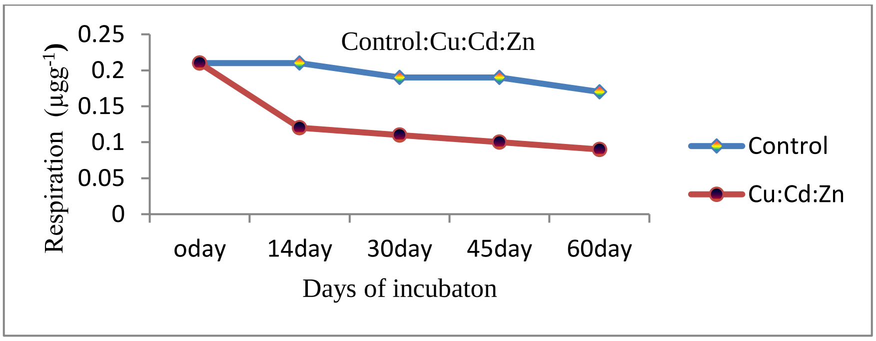

Figure 7. Changes of respiration in soil due to application of (Cu:Cd:Zn).

Figure 7 also shows significant ($p \leq 0.01$) changes in respiration due to the application of (Cu:Cd:Zn) (3000$mgkg^{-1}$) as well as with the days of incubation. The lowest value (0.09 μgg^{-1}) was found at 60 days.

Conclusion

It can be concluded that the activity of soil respiration is adversely affected by heavy metals because of decreasing the effects of microbial activity in heavy metals contaminated soil day by day.

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