Soil environments affected by copper recycling activities, Dai Dong village, Van lam District, Haoi Hun Province, Vietnam

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Abstract

Copper (Cu) recycling is a cottage industry in Dai Dong village. This activity causes soil contamination. In order to be able to evaluate the seriousness of this problem, the authors investigated the immediate neighborhood of the village. Soil and surface water samples were collected in the area surrounding the village along four transects orientated southeast, northwest, northeast and southwest. Samples were taken at distances of 0, 50, 100, 150, 200 and 300m from the village. Measured Cu contents were high. The highest Cu contents were found along the southeast orientated transect with soil Cu concentrations ranging from 237.8 mg kg^{-1} at distance of 300m to 375.02 mg kg^{-1} near the village. The lowest content of copper was found along the northeast orientated transect with soil Cu concentrations of 97.18 mg kg^{-1} at 300m from the village and 167.87 mg kg^{-1} near the village. Soil total and available Cu contents decrease significantly with increasing distance from the village. The ratio between total and available copper is 3:1. On a wider scale, the total soil Cu concentration in an area of 0.6 km radius around village is estimated to be over 60 mg kg^{-1}.

Introduction

Recycling of heavy metals has been on the increase in many small villages around Hanoi and in other areas of Vietnam. Due to the high economic return from this activity, outputs have increased without any regard for the environment. This carries with it the potential for future environmental damage and contamination of the soil, surface and groundwater.

Dai Dong village belongs to Hung Yen District, Haoi Hun Province, at a distance of about 12 km from National Highway No 5. The village covers an area of 7,000 ha and has an estimated resident population of 8,275. The village household economy is based on agriculture, with main crops being paddy rice, corn, sweet potato, and vegetables. Dai Dong village has been recycling Cu for > 60 years. Currently, 45 households or approximately 33% of the village are recycling Cu. The total Cu output for the village is estimated at 360 t yr^{-1}. With the rudimentary equipment and technologies adopted and absence of emissions and disposal controls it may be expected that the area within and adjacent to Dai Dong village is significantly contaminated with Cu.

During the Cu recycling and manufacturing process adopted in Dai Dong village there are two stages that can cause environmental pollution. The first is when the copper scrap is heated to a temperature of 1500^{o}C. Copper fumes escape and contaminate air, soil and water resources. The second stage is at the preparation of the final product when polishing and 'shaping' take place. Fine Cu cuttings are lost and not recovered and cause direct contamination of the soils and water.

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Sampling method

Soil samples were taken at a depth of 0-20 cm at 0, 50, 100, 150, 200 and 300m distance along four transects orientated Southeast (SE), Northwest (NW), Northeast (NE) and Southwest (SW) from the centre of the village. Surface water samples were taken at the same site as soil samples. Total-Cu and available-Cu were determined using colorimetric methods. In addition, pH_{KCL}, Organic Matter Content (OMC), soil texture and CEC were determined using standard analytical methods.

Main properties of soil

Soils used in the study are alluvial, formed by river sedimentation. Soils have a clay fraction of 58% and a sand fraction of 42% dry soil weight. In addition, soil CEC ranges from 15.57-19.5 meq $100g^{-1}$ dry soil.

Results and Discussion

Soil pH_{KCl} are relatively stable ranging from pH 4.91 – 5.89 irrespective of sampling location (Table 1). Soil OMC ranged from 2.27 to 3.40 % in the surface 0-20 cm. The highest OMC value is found along the NE orientated transect approximately 50m from the village.

Table 1. pH_{KCl} in the top soil (0-20cm)

Transect Orientation	Distance from the village (m)						
	0	50	100	150	200	300	Mean
SW	5.24	5.22	5.52	5.25	5.20	5.49	5.34
NW	5.13	5.59	5.63	5.48	5.07	5.56	5.41
SE	5.46	4.91	5.25	5.74	5.09	5.26	5.29
NE	5.13	5.89	5.63	5.48	5.07	5.56	5.46
Mean	5.24	5.40	5.51	5.49	5.11	5.47	5.37

Table 2. Total organic matter content (OMC) % in the soil at 0-20 cm depth.

Transect Orientation	Distance from the village (m)						
	0	50	100	150	200	300	Mean
SW	2.27	2.94	2.37	4.03	3.51	2.53	2.94
NW	2.37	2.48	2.37	2.99	2.06	2.27	2.42
SE	3.42	3.10	2.27	2.06	1.55	2.43	2.47
NE	2.63	5.06	3.05	2.58	2.89	1.86	3.01
Mean	2.67	3.40	2.52	2.92	2.50	2.27	2.71

Soil Cu concentration

Total soil Cu ranged from 237.81 - 375.02 mg kg^{-1}, 124.62 - 160.7 mg kg^{-1}, 149.78 - 232.1 mg kg^{-1} and 97.18 - 168.07 mg kg^{-1} for the SW, NW, SE and NE orientated transects, respectively (Figures 1 a-d). Available soil Cu although approximately 30% of Total-Cu shows a similar spatial distribution. Copper contents in soils are high, well over the critical standards set by the Department of Science and Technology in Hanoi.

Figure 1a-d. Soil Total-Cu and Available-Cu concentrations (mg kg^{-1}) in relation to transect orientation.

Figure 1a. SW sampling transect

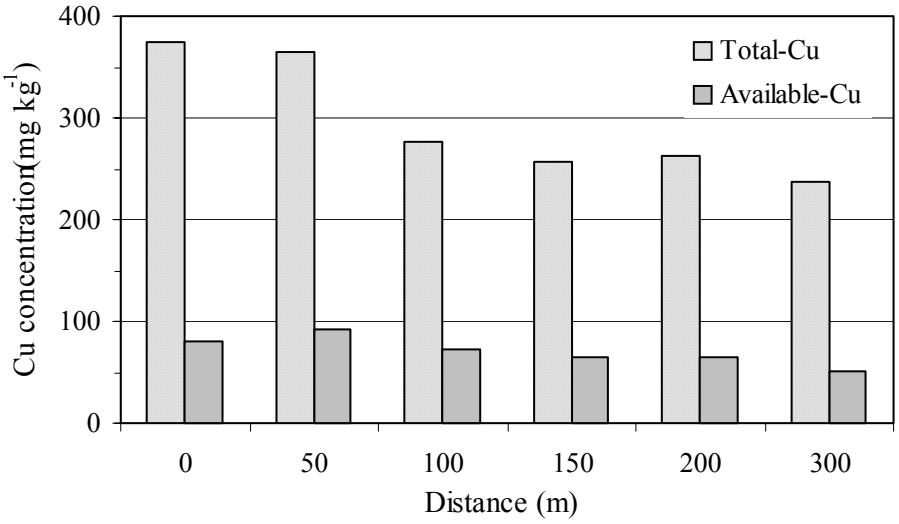


Figure 1b. SE sampling transect

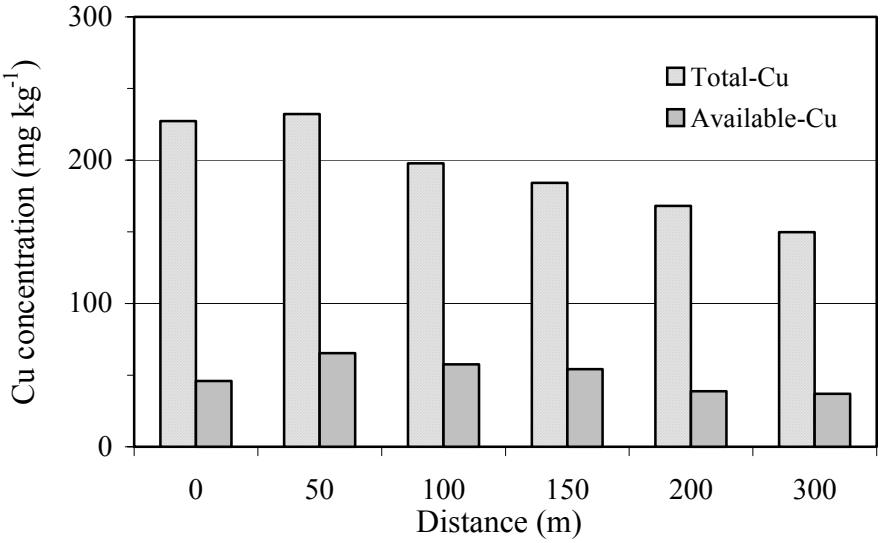


Figure 1c. NW sampling transect

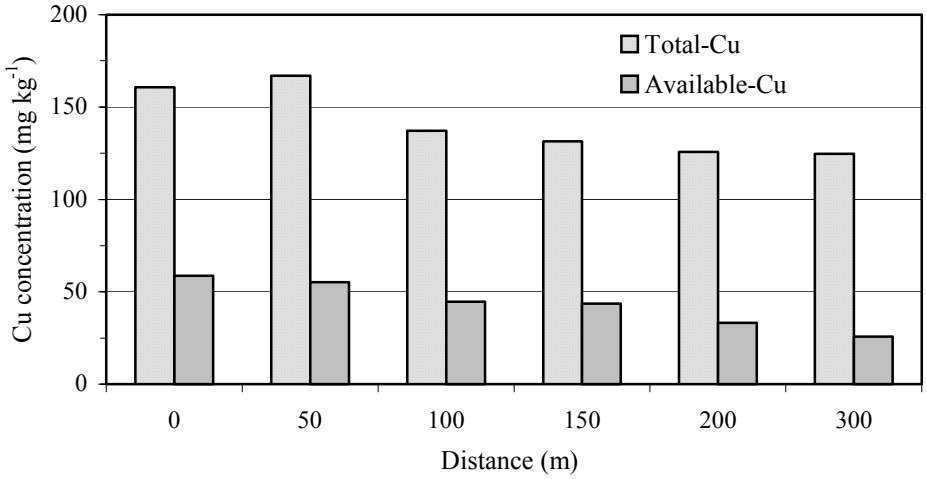


Figure 1d. NE sampling transect

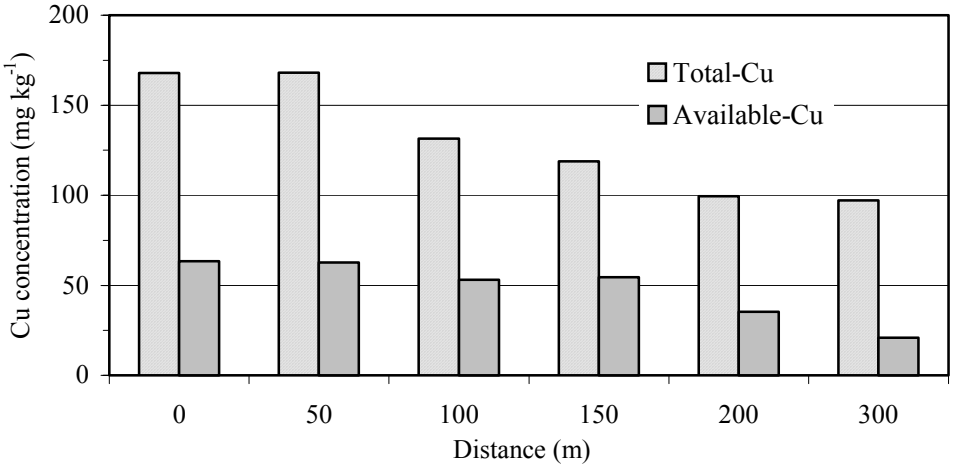


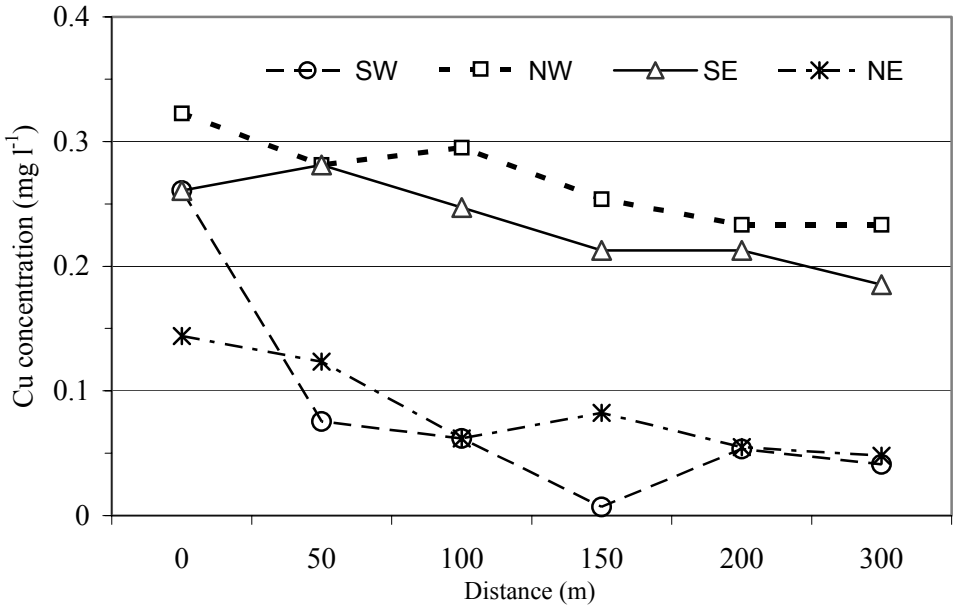
Table 3. Vietnamese provisional maximum permissible concentrations for total Cu in the soil

Soil pH	Maximum Permissible concentration (mg kg^{-1})	Soil pH	Maximum Permissible concentration (mg kg^{-1})
3.5	< 15	6.0	< 120
4.0	< 20	6.2	< 180
4.5	< 25	6.5	< 250
5.0	< 40	7.0	< 260
5.5	< 60	7.5	< 270
5.7	< 80	8.0	< 280

Copper concentrations in (Cu^{2+}) in surface water

Surface water samples were collected at the same sampling points as the soils. The assay results for these water samples are presented in Figure 2.

Figure 4. Concentration of Cu in surface water samples (mg l^{-1}) collected adjacent to Dai Dong Village, Hung Yen District, Haoi Hun Province, Vietnam.



Copper in surface water averages ranges from 0.0083-0.2698 mg l^{-1}. In addition, surface water Cu concentrations decrease significantly with increasing distance from Dai Dong village. Further, pH of the water samples collected ranges from pH 7.0-7.4. This significantly affects the Cu-solubility which is higher under acidic conditions. The highest copper values in surface water samples were observed along the NW orientated sampling transect.

Conclusions

Soil total and available Cu concentrations decrease with increasing distance from Dai Dong village. Soil Cu concentrations at all locations sampled significantly exceed the Vietnamese provisional maximum permissible concentrations for Total-Cu in the soil. The agricultural soils adjacent to Dai Dong village therefore may be considered to be contaminated and remediation measures should be implemented.

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