UNIVERSITI PUTRA MALAYSIA

ASSESSMENT OF HEAVY METAL CONTAMINATION IN SOILS AND VEGETABLES IN CAMERON HIGHLANDS VEGETABLE FARMS

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DEDICATION

This work is dedicated to my great mother
Hadimi Amina Binti Moulay Abdelkader

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master Agricultural Science

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Chairman: Professor Dr. Shamshuddin Jusop
Faculty: Agriculture

Vegetable cultivation is the most important agricultural activity in Cameron Highlands; about 64% of the population are involved in vegetable cultivation, with a total area of 2 599 hectares. Due to the extensive land levelling and construction of terraces, the vegetables are essentially grown on the subsoil. The subsoil are mainly sandy clay or clay, with large amounts of organic matter being added usually in the form of chicken manure.

In a study of assessment of heavy metals in soils and vegetables of Cameron Highlands, Peninsular Malaysia, 200 soil and 40 vegetable samples from various locations were analyzed for cation exchange capacity (CEC), texture, cadmium (Cd), copper (Cu), nickel (Ni), lead (Pb), chromium (Cr) and zinc (Zn), organic carbon (OC), pH and available phosphorus (P). The results showed that there was no relationship between total Cd, Cr, Cu, Ni, Pb and Zn concentrations in the soils and in the vegetables. Correlation studies of soil fertility parameters and total heavy metal concentration showed positive correlation between total P and Pb (r =0.492*) and Ni (r = 0.514*). This

is indicative of addition of these metals as impurities in organic and inorganic fertilizers Organic Cd showed a positive correlation (r = 0.538*) with soil carbon (OC), while Pb showed a negative correlation (r = - 0.507*). This is indicative of addition of Cd as impurities in organic manures.

Copper was positively correlated with clay content (r = 0.678**), while Pb (r = -0.484*) and Ni (r = -0.554*) were negatively correlated with Al. Pb was negatively correlated with CEC (r = -0.502*). Anova analysis of total Zn, Cd, Cu, Cr, Ni and Pb with soil depth showed a very strong positive relationship. The concentration of Zn, Cd, Cr and Cu are high only in the topsoil (0-20 cm), but the concentration of these elements remain the same in the depths of 20-40 cm and 40-60 cm. This is indicative of the contamination from agriculture activities. The difference in heavy metals from the cultivated soils and the control (primary forest) provides further evidence of the contamination by agriculture activities.

The concentrations of heavy metal in Cameron Highlands soils from different vegetable farms were studied. Brinchang and Tanah Rata vegetable farms had very high concentration of Zn (219.80 mg/kg); in Brinchang it is above the background values (Dutch Standard Guidelines). Also Brinchang and Tanah Rata farms had very high concentration of Cu (61.80 and 71.20 mg/kg, respectively), which is above the background level. Cd tends to be high in all Cameron Highlands farm soils.

The concentration of heavy metals in cabbage from Blue Valley had the highest concentration of Zn (133.99 mg/kg), while Tring Cap cabbage had the lowest concentration (73.01 mg/kg). Bertam Valley cabbage had the highest concentration of

Pb (1.50 mg/kg), while the lowest concentration (0.26 mg/kg) occurs in the Blue Valley cabbage. Bertam Valley cabbage had also the highest concentration of Cd (0.55 mg/kg), while the lowest concentration (0.18 mg/kg) was found in the Blue Valley cabbage.

Jalin Trisu cabbage had the highest concentration of Ni (10.26 mg/kg), while the lowest concentration (4.78 mg/kg) was in the Blue Valley cabbage. Finally, Taman Sadia cabbage had the highest concentration of Cu (92.66 mg/kg), while the lowest concentration (5.01 mg/kg) was in the Kea Farm cabbage.

It can be considered that Cameron Highlands vegetables planted on contaminated soils are not harmful for human consumption.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia Sebagai memenuhi syarat ijazah Master Sains Pertanian

PENILAIAN KONTAMINASI LOGAM BERAT DALAM TANAH DAN SAYUR-SAYURAN DI LADANG SAYUR DI CAMERON HIGHLANDS

Oleh

EL IDRISSI ABOUJAAFAR SIDI MOHAMED

Oktober 2002

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Pengeluaran sayur-sayuran merupakan aktiviti pertanian utama di Cameron Hiaghlands. Lebih kurang 64% daripada pendudukanya tertibat, dengan keluasan kawasan sebanyak 2599/hektar. Oleh kerana proses meratakan tanah yang melampau dan pembinaran teres, sayur-sayuran sebenarnya ditanam di atas subtanah. Subtanah ini kebanyakanya lempung berpasir dan lempung yang dibajakan dengan jumlah bahan organik yang tingi dalam bentuk tahi ayam.

Kenpayaan pertukaran kation (KPK), tekstur, Cd, Cu, Ni, Pb, Cr, Zn, karbon organik, pH dan P tersedia telah dianalisis dalam satu hajian untuk menilai logam berat dalam tanah dan sayur di Cameron Highlands, semenanjung Malaysia. Sebanyak 200 contoh pilih dan 40 contoh sayur daripada beberapa lokasi telah dipili. Didapati tiada

kaitan diantara kepekatan Cd, Cr, Cu, Ni, Pb, dan Zn total di dalam tanah dan sayuran. Kajian korelasi diantara parameter kesuburan dan kepekatan logam berat total menunjukkan korelasi positif di antara P total dan Pb (r =0.492*) dan Ni (r = 0.514*). Ini menunjukkan penambahan logam berat tersebut sebagai bahan kotoran racum fosfat nitro. Cadmium organik berkorelasi positif (r = 0.538*) dengan karbon organik, manakala Pb berkorelasi negatif (r = - 0.507*). Ini juga menunjukkan pertambahan Cd sebagai bahan kotoran dalam baja organik.

Kuprum bercorelasi positif dengan kandungan lempung (r = 0.678**), manakala Pb (r = -0.484*) dan Ni (r = -0.554*) berkorelasi negatif dengan Al. Pb berkorelasi negatif dengan KPK (r = -0.502*). Analisis ANOVA Zn, Cd, Cu, Cr, Ni dan Pb dengan kedalaman tanah menunjukkan pertalian positif yang kuat. Kepekatan Zn, Cd, Cr dan Cu tinggi dalam tanah atas (0-20 cm), tetapi kepekatan elemen ini pada kedalaman 20-40 dan 40-60 cm tidak berubah. Ini menunjukkan kontaminasi daripada aktiviti pertanian. Perbezaan logam berat dalam tanah pertanian dengan contoh kawalan (hutan primer) boleh di gunakan sebagai bukti tambahan.

Kepekatan logam berat dalam tanah Cameron Highlands daripada ladang sayuran telah dikaji. Ladang sayur Brinchang dan Tanah Rata mengandungi kepakatan Zn yang sangat tingi (219.80 mg/kg); di Brinchang ianya melebehi nilai asas A (Dutch Standard Guidelines). Di samping itu juga, ladang sayur Brinchang dan Tanah Rata mengandungi Cu yang sangat tinggi (masing-masing bernilai 61.80 dan 71.20 mg/kg), berada di atas nilai asas. Cd di dapati agak tinggi dalam tanah sayuran di Cameron Highlands.

Kubis daripada ladang Blue Valley mengandungi Zn tertinggi (133.99 mg/kg), manakala kubis daripada Tring Cap mengandungi Zn terendah (73.01 mg/kg). Kubis daripada Bertam Valley mengandungi Pb tertinggi (1.50 mg/kg), manakala kubis daripada Blue Valley mengandungi Pb terendah (0.26 mg/kg). Kubis daripada Bertam Valley mengandungi Cd yang tertinggi (0.55 mg/kg), manakala kubis daripada Blue Valley mengandungi Cd terendah (0.18 mg/kg). Kubis daripada Jalin Trisu mengandungi Ni tertinggi (10.26 mg/kg), manakala kubis daripada Blue Valley mengandungi Ni terendah (4.78 mg/kg). Akhir sekali, kubis daripada Taman Sadia mengandungi Cu tertinggi (92.66 mg/kg), manakala kubis daripada Kea Farm mengandungi Cu terendah (5.01 mg/kg).

Adalah boleh dianggap bahawa sayur di Cameron Highlands yang ditanam di atas tanah tercemar tidak merbahaya untuk dimakan

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LIST OF ABBREVIATIONS

ANOVA	analysis of variance
HCl	acid hydrochloric
HNO_3	acid nitric
mg/kg	milligram per kilogram
µg/l	microgram per liter
l	liter
ml	milliliter
kg	kilogram
g	gram
cm	centimeter
mm	millimeter
dw	dry weight
P	phosphorus
K	potassium
Ca	calcium
Cu	copper
Cr	chromium
Cd	cadmium
Ni	nickel
Zn	zinc
CEC	cation exchange capacity
AAS	atomic absorption spectrophotometer
ICP	inductively coupled plasma
Al	aluminum
OC	organic carbon

CHAPTER I

INTRODUCTION

1.1 General introduction

Cameron Highlands was discovered by Mr William Cameron in 1885. Subsequently, it was revisited in 1908 by H.N.Ridley who studied the flora around Ringlet and the Bertam Valley. In 1922 an expedition was organized to locate areas for tea and coffee cultivation (Sands, 1922). The soils collected by Sands (1922) were analyzed and studied. The soils were reported to be distinctly different from other Malaysian soils, but resembled the best tea soils of India and Java. The first real study of the soils of the Cameron Highlands was made by Dennet (1930) when he produced a sketch map showing the distribution of the soils according to their texture.

The variation in soils as a function of altitude was studied by Burnham (1974). He concluded that weathering became less intense with an increase in altitude as shown by lower clay and higher silt and sand in the soils, and the appearance of saprolite with depths. He added that parallel changes in clay mineralogy give higher CEC and water dispersibility so that there are no Oxisols in Malaysia above 1,200 meters (around 4,000 ft). Leaching is very strong at all elevations, particularly at the higher elevations but clay eluviations is not significant in the profiles studied. However, Burnham (1974) added that elevation of iron and aluminum is important in the soils of the cloud zone. Burnham (1974), however, did not attempt to explain these observations.

Cameron Highlands is situated in mountainous area with elevation exceeding 1000 m asl. The area experiences mild temperature, ranging from 14 °C to 24 °C throughout the year, making it very conducive to the growth of a wide range of sub-tropical crops. Most of the Cameron Highlands area can be classified as steep lands, with more than 66% of the land having gradients greater than 20°. Steep lands are generally not recommended for agriculture, but the favorable cool climate has encouraged the growth of several agricultural activities in the area.

There is an intensive form of agriculture being practiced in Cameron Highlands especially for the cultivation of vegetables, flowers and tea. Most of the vegetables are grown on terraces cut into granite hills. Often these terraces are on the C-horizon or saprolite. Large inputs of chicken manures and chemical fertilizers are added to sustain the vegetable cultivation.

Although agriculture takes only about 7 % of the area, it has caused a significant amount of environmental pollution. The initial opening of forested areas resulted in intensive soil erosion. Erosion continues to be a problem during the cultivation of vegetables or other short-term crops. Soil loss exceeds 83 tonnes per hectare every year in open cabbage farms (Wan Abdullah *et al.*, 2000). The erosion under tea is low, while that in chrysanthemum farms under the rain shelter is less than 1 tonne per hectare per year, which is about 80 times smaller than that in the open vegetable farms (Wan Abdullah *et al.*, 2000). High amounts of organic fertilizers ranging from 49 to 84 tonnes per hectare per season are used in vegetable and flower farms, about 3.2% (43 kg/ha) of the applied N and 5.5 % (109 kg/ha) of the applied K were removed through runoff (Wan Abdullah et al., 2000).

During peak runoff periods, the concentration of NO_3^- in runoff water reaches 25 mg/kg, exceeding the permissible limit (Wan Abdullah *et al.*, 2000). This is an indication that open vegetables farms in Cameron Highlands and the long-term addition of fertilizers either organic or inorganic such as phosphate rock, chicken dung and other kind of fertilizers may accumulate heavy metals in the soil.

Farm land in Cameron Highlands is increasingly being brought under plastic cover to keep rain out. It is estimated that there are about 777 ha under highland flower cultivation, of which almost the entire grown area is under rainshelter. A much smaller area under rainshelter is devoted to the growing of vegetables and ornamental plants (Wan Abdullah *et al.*, 2000). Given a choice, farmers will always prefer their land to be under rainshelter. Growing of crops under rainshelter offers many advantages. It avoids hazards associated with untimely rains and planting density is also higher as most rainshelters are built on flat and gently sloping platforms carved out of hillsides. Generally, cropping cycles are also faster. For chrysanthemum, each cropping cycle is about 3.5 months with 10-14 days break between seasons to allow for soil treatment and field preparation. The cropping cycle for some leafy vegetables can be as short as about a month. Rainshelter also offers a relatively more conducive working environment compared to open terraces (Wan Abdullah *et al.*, 2000).

Intensive cropping cycle are accompanied by high inputs of fertilizers and other agrobiocides. Much of these inputs slowly accumulate over time in the soil. Except for vegetable growing where crop rotation is practiced, flower farmers tend to grow the same type of flower on a continuous basis. This leads to a high accumulation of fertilizers in the soils given that natural leaching via rainfall and irrigation is minimal. This results in salt build up in the soil giving rise to high electrical conductivity. Salt accumulation in soils under plastic houses is a common and well documented occurrence (Chang and Liao, 1989).

1.2 Objectives

The objectives of this study were:

a. To determine the level of heavy metal concentration in the agricultural soils commonly grown with vegetables in the Cameron Highlands;

b. To determine among the heavy metals in the soils, those which are available to be taken up by the plants; and

c. To determine the relationship between the heavy metals in the soils and the vegetables

1.3 Hypothesis

The agricultural practices are the main factors that contribute to heavy metal contamination in the soils and vegetables of Cameron Highlands.