Risk Assessment of Soils after Changing Agricultural Land Use in Hong Kong

MAN Yu Bon

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Principal Supervisor: Dr. CHEUNG Kwai Chung

Hong Kong Baptist University

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Abstract

The objective of this study was to evaluate the consequence of changing land use from agriculture to other purposes in Hong Kong with respect to risk to human health. This study established concentrations of the following priority elements: As, Cu, Cd, Cr, Pb and Zn in terms of total burden (using mixed acid microwave digestion) and with respect to metal bioaccessibility (using an in vitro simulated gastric solution). In addition, total concentrations of PAHs, PCDD/Fs, DDTs, OCPs, PBDEs and PCBs in terms of total burden (using Soxhlet extraction) and their bioaccessibility (using an in vitro simulated gastric solution) were analyzed. There were 55 sample locations, representing 12 different land use types, namely, agricultural (A), abandoned agricultural (Ab), organic farm (OF), container storage (CS), construction waste (CW), e-waste storage (EW (S)), e-waste dismantling workshop (EW (DW)), e-waste open burning site (EW (OBS)), open burning site (OBS), petrol station (PS), metal recycling workshop (MRW) and car dismantling workshop (CDW).

The pollutant concentrations were subsequently used to establish non-cancer risk (for adults and children) and cancer risk probabilities on humans by combining the three exposure pathways, namely ingestion, dermal and inhalation. The 95th centile values of Hazard Index (HI) of total elemental concentrations showed increased potential harm (HI = 1.16) for adults in EW (DW), while EW (OBS) and CDW illustrated the most elevated non-cancer risks to children at 5th centile (1.81 and 2.04 accordingly). Furthermore, PCDD/Fs WHO- TEQ levels in OBS and EW (OBS) indicated that HI far exceeded the unity with levels of 47.7 and 7.50 for adults, and 345 and 54.3 for children respectively. At 95th centile, soils of total elemental
concentrations (As, Cd and Cr) from A, EW (DW) and CDW registered relatively high cancer risks \(3.88 \times 10^{-4}, 4.63 \times 10^{-4}\) and \(4.02 \times 10^{-4}\) accordingly). Soil total PAHs in CDW indicated a high potential for cancer development (1420 in one million people). In addition, the levels of 17 PCDD/Fs congeners in OBS and CDW soils indicated high and moderate (6203 and 975 in one million people) cancer risks. There were very low cancer risk of OCPs (DDTs + HCHs) based on their total burdens in all samples. Nonetheless, there were significant correlations of DDT to its metabolites (DDE and DDD) (\(r = 0.506\) and \(r = 0.648\) at \(p < 0.01\)) and DDE to DDD (\(r = 0.438\) at \(p < 0.01\)). Hence, fresh deposition of DDTs cannot be ruled out. OCPs levels should be routinely monitored in different environmental media and food in order to verify whether there is fresh input. It was found that very low cancer risk was caused by BDE-209 in different types of land uses. Nevertheless, at 95th centile, PCBs level in EW (DW) and EW (OBS) indicated a low cancer risk on humans (40 and 2.1 in a million of people).

Results showed that CDW soil had 39 and 50 % seed germination inhibition for Lactuca sativa and Brassica chinensis compared to the control, whereas EW (OBS) had 21 and 11 %, respectively. In CDW soil, root length inhibition compared to the control were 78, 87 and 97 % of Lactuca sativa, Lolium perenne and Brassica chinensis whereas EW (OBS) soil were 33, 15 and 52% and EW (DW) soil were 38, 19 and 41 %, accordingly.

Ames test (Salmonella mutagenicity) manifested that CDW soil had high mutagenic potency of 17.7 and 9.37 on both strains of TA 98 and TA 100, respectively, and relatively lower mutagenicity was observed for OBS and EW (DW) soils, with a mutagenic potency of 3.10 and 4.13, and 3.35 and 3.94, accordingly.
SOS-ChromoTest indicated that soils of OBS, EW (DW), EW (OBS) and CDW had a relatively high genotoxicity (SOS Inducing Potency (1.01, 1.09, 1.56 and 1.68 respectively)). EROD assay-derived 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) concentrations of the samples showed that OBS and EW (OBS) revealed the relatively high bioassay derived TCDD concentrations (935 and 517 pg/g). Based on the results of risk assessment and bioassay tests, soils from OBS, EW (DW), EW (OBS) and CDW showed the most prominent non-cancer risk, cancer risk, plant growth inhibition, mutagenicity, genotoxicity and EROD assay-derived TCDD concentration. This suggested that changing agricultural lands to these types of land use might give rise to the most serious environmental and human health concerns.
# Table of contents

Declaration .................................................................................................................. i

Abstract .................................................................................................................. ii

Acknowledgements .................................................................................................. v

Table of Contents ..................................................................................................... vi

List of Tables ............................................................................................................ xv

List of Figures .......................................................................................................... xx

Abbreviations .......................................................................................................... xxii

## Chapter 1 GENERAL INTRODUCTION ......................................................... 1

1.1 Hong Kong Landscape and Local Agricultural Produces ....................... 1

1.2 Background Information of Agricultural Development in Hong Kong ....... 2

1.3 Reasons for the Decline of Local Agricultural Produces ......................... 2

1.4 Changing of Agricultural Land Use ............................................................... 4

1.5 Values of Farm Land ...................................................................................... 5

1.5.1 Food Production ...................................................................................... 5

1.5.2 Scenic and Aesthetic Values .................................................................. 5

1.5.3 Recreational Activity and Psychological Relief ....................................... 6

1.5.4 Ecological Value ..................................................................................... 6

1.5.5 Benefit from Carrying Agricultural Activities ........................................... 6

1.6 Background Information on Heavy Metals ................................................ 8

1.6.1 Heavy metal Contamination in Agricultural Soil .................................... 9

1.6.2 Health Effects of Heavy Metals on Human ............................................. 9

1.7 Background Information of Persistent Toxic Substances ....................... 10

1.7.1 Polycyclic Aromatic Hydrocarbons (PAHs) ......................................... 11
1.7.2 Organochlorine Pesticides (OCPs)………………………………………13
1.7.3 Polybrominated Diphenyl Ethers (PBDEs)………………………….14
1.7.4 Polychlorinated Biphenyls (PCBs)……………………………………15
1.7.5 Polychlorinated Dibenzo Dioxins (PCDDs) and Polychlorinated Dibenzo furans (PCDFs)……………………………………………………16

1.8 Geographic Information System (GIS) Spatial Analyses…………………17
1.9 Concerns of Human Health Risk of Changing Agricultural Land Use………17
1.10 Risk Characterization and Estimation……………………………………18
1.10.1 Possible Exposure Pathways…………………………………………18
1.10.2 Equations of Non-Cancer Risk Assessment on Humans via Ingestion, Dermal Contact and Inhalation……………………………………..20
1.10.3 Choosing Appropriate Parameters for Estimating the Non-cancer Risk……………………………………………………………………..21
1.10.4 Using Average Daily Dose and Reference Dose to Estimate the Hazard Quotient………………………………………………………21
1.10.5 Combination of Different Hazard Quotients (HQ) to Generate Hazard Index (HI) across Different Exposure Pathways……………….23
1.10.6 Equation of Cancer Risk Assessment on Human via Ingestion, Dermal Contact and Inhalation………………………………………………26

1.11 Toxicity Assessments Using Different Bioassay…………………………27
1.11.1 Seed Germination and Root Elongation Test…………………………29
1.11.2 Ames Test………………………………………………………………..29
1.11.3 SOS Chromotest………………………………………………………..30
1.11.4 Ethoxyresorufin-O-deethylase (EROD) assay…………………….31

1.12 Objective of This Study………………………………………………….31
1.13 Framework………………………………………………………………33

Chapter 2 RISK ASSESSMENT OF HEAVY METALS AFTER CHANGING OF AGRICULTURAL LAND USE…………………………….35

2.1 Introduction………………………………………………………………35
2.2 Materials and Methods.................................................................37
  2.2.1 Soil Sampling.................................................................37
  2.2.2 Physicochemical Properties of Soils and Chemical Analyses........37
  2.2.3 Quality Control..............................................................41
  2.2.4 Nemerow’s Pollution Index...............................................41
  2.2.5 Geographic Information System Spatial Analyses.........................43
  2.2.6 Risk Assessment of Heavy Metals........................................44
  2.2.7 In Vitro Digestion Model..................................................44
  2.2.8 Selection of Soil Samples for In Vitro Digestion Model and Recoveries of Standard Reference Materials and Risk Assessment........46
2.3 Results and Discussion...............................................................47
  2.3.1 Physicochemical Soil Properties........................................47
  2.3.2 Approach to Evaluate the Risk of Heavy Metals and Metalloid in Different Types of Agricultural Land Use in Hong Kong...............52
  2.3.3 Heavy Metals and Metalloid Concentrations in 12 Different Types of Agricultural Land Use......................................................53
  2.3.4 Soil Pollution Index (SPI) in 12 Different Types of Agricultural Land Use............................................................................57
  2.3.5 Heavy Metals Geographic Information System (GIS) Maps...........59
  2.3.6 Non-Cancer Risk Assessment on Adults..................................59
  2.3.7 Non-Cancer Risk Assessment on Children...............................63
  2.3.8 Underestimation of Non-Cancer Risk through Inhalation of Soils.....65
  2.3.9 Approach on Accessing Non-Cancer Risk of Lead on Human........68
  2.3.10 Cancer Risk Assessment on Humans......................................69
  2.3.11 Bioaccessible Heavy Metals.............................................71
  2.3.12 Non-Cancer risk assessment of Bioaccessible Heavy Metals.......73
  2.3.13 Cancer Risk Assessment of Bioaccessible Heavy Metals............73
2.3.14 Using Bioavailable and Bioaccessible Heavy Metals to Conduct Risk Assessment.................................................................76

2.4 Conclusion........................................................................................................77

Chapter 3 POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) AND POLYCHLORINATED DIBENZO-P-DIOXINS AND POLYCHLORINATED DIBENZOFURAN (PCDD/Fs) IN AGRICULTURAL SOIL AND RISK ASSESSMENT..............79

3.1 Introduction......................................................................................................79

3.2 Materials and Methods..................................................................................81
  3.2.1 Sampling, Preparation and Analysis.......................................................81
  3.2.2 Total PAHs Extraction and Analysis.......................................................81
  3.2.3 Quality Control......................................................................................83
  3.2.4 Geographic Information System Spatial Analyses..................................83
  3.2.5 Risk Characterization and Estimation.....................................................83
  3.2.6 In Vitro Digestion Model to Extract Bioaccessible PAHs.......................84
  3.2.7 Selection of Soil Samples for In Vitro Digestion Model, Bioaccessible PAHs Recoveries and Risk Assessment of Bioaccessible PAHs..........................................................86
  3.2.8 Criteria of Choosing soil Samples for the Analysis of Total PCDD/F and Risk Assessment..........................................................87

3.3 Results and Discussion..................................................................................89
  3.3.1 Concentration of Total PAHs of the Twelve Types of Land Use...........89
  3.3.2 Correlation of PAHs with Soil Organic Matter........................................93
  3.3.3 Profile of PAHs..........................................94
  3.3.4 PAHs Geographic Information System (GIS) Maps.............................96
  3.3.5 Non-Cancer Risk of PAHs.................................................................101
  3.3.6 Cancer Risk of PAHs......................................................................103
    3.3.6.1 Cancer Risk of PAHs through Ingestion of Soil.................103
    3.3.6.2 Cancer risk of PAHs through Dermal Contact of Soil..........103
    3.3.6.3 Cancer risk of PAHs through Inhalation of Soil.................105
3.3.6.4 Cancer Risk of PAHs through Total Exposure Pathways of Ingestion, Dermal Contact and Inhalation of Soil………………………105

3.3.7 Bioaccessible Concentrations of PAHs……………………………………108

3.3.8 Bioaccessible Concentrations of PAHs Cancer Risk through Ingestion of Soils………………………………………………………108

3.3.9 Concentrations of PCDD/Fs on 12 Different Types of Land Use….112

3.3.10 Non-cancer and cancer Risk assessment of PCDD/Fs………………..116

3.4 Conclusion…………………………………………………………………………118

Chapter 4 BIOMAGNIFICATION, DEGRADATION AND HEALTH RISK ASSESSMENT OF ORGANOCHLORINE PESTICIDES WITH EMPHASIS ON DDTS AND HCHs IN ABANDONED AGRICULTURAL SOILS……………………………119

4.1 Introduction……………………………………………………………………119

4.2 Materials and Methods………………………………………………………121

4.2.1 Sampling, Preparation and Analysis……………………………………121

4.2.2 Extraction and Analyses of Total DDTs and HCHs…………………..121

4.2.3 Quality Control……………………………………………………………..122

4.2.4 Geographic Information System Spatial Analyses…………………...122

4.2.5 Risk Characterization and Estimation…………………………………123

4.2.6 Bioaccessible OCPs Determination and Risk Assessment…………123

4.3 Results and Discussion…………………………………………………………125

4.3.1 Biomagnification of DDTs and HCHs in the local food chain………125

4.3.2 Concentrations of DDTs and HCHs in Former and Current Agricultural Soils…………………………………………………………126

4.3.3 Reason of Elevated DDTs in Farm Soils………………………………126

4.3.4 Correlation Matrix of OCPs with Soil Organic Matter and Geographic Information System (GIS) Maps of OCPs……………………………..129

4.3.5 Degradation Pathways of DDTs………………………………………133

4.3.6 Fresh Input of DDTs on the Local Soils?……………………………..135
4.3.7 Non-Cancer Risk assessment of OCPs.................................138
4.3.8 Cancer Risk Assessment of OCPs.................................140
4.4 Conclusion........................................................................142

Chapter 5 RISK ASSESSMENT OF POLYBROMINATED DIPHENYL
ETHERS AND POLYCHLORINATED BIPHENYL OF
ELECTRONIC-WASTE AND OPEN BURNING SITES.............143

5.1 Introduction.......................................................................143
5.2 Materials and Methods.....................................................145
  5.2.1 Sampling, Preparation and Analysis............................145
  5.2.2 Total PBDEs and PCBs Extraction and Analysis.............147
  5.2.3 Quality Control............................................................148
  5.2.4 Risk Characterization and Estimation..........................149
  5.2.5 In Vitro Digestion Model to Extract Bioaccessible PCBs.....149
  5.2.6 Selection of Soil Samples for In Vitro Digestion Model, Bioaccessible
  PCBs Recoveries and Risk assessment of Bioaccessible PCBs......152
5.3 Results and Discussion....................................................152
  5.3.1 Concentrations of PBDEs in Different Types of Land Use.....152
  5.3.2 Concentrations of PCBs in Different Types of Land Use.......157
  5.3.3 Soil Organic Matter with PBDEs and PCBs......................160
  5.3.4 Non-Cancer Risk Assessment of PBDEs.........................163
  5.3.5 Cancer Risk Assessment of PBDEs.................................163
  5.3.6 Cancer Risk Assessment of Total PCBs.........................168
  5.3.7 Cancer Risk Assessment of Bioaccessible PCBs...............171
5.4 Conclusion.......................................................................173

Chapter 6 TOXICITY TESTS ON SOIL SAMPLES OF 12 DIFFERENT
TYPES OF LAND USE............................................................174

6.1 Introduction.................................................................174
6.2 Materials and Methods...................................................177
6.2.1 Criteria for Choosing Soil Samples for Toxicity Tests

6.2.2 Seed Germination and Root Elongation Test

6.2.2.1 Selection of Seeds for the Seed Germination and Root Elongation Test

6.2.2.2 Experimental Procedure for the Seed Germination and Root Elongation Test

6.2.2.3 Interpretation of Seed Germination and Root Elongation Data

6.2.3 Extraction of DTPA-Extractable Metals

6.2.4 Extraction of Soil Samples for Ames Test and SOS ChromoTest and Preparation of S9 Mix

6.2.5 Ames Test

6.2.5.1 Criteria to Indicate Mutagenicity of the Soil Samples in Ames Test

6.2.5.2 Preparation of Medium and Reactive of TA 98 and TA100

6.2.5.3 Mixing Soil Extracts with TA98 or TA100 ± S9 Mix

6.2.6 SOS-Chromo Test

6.2.6.1 Criteria to Indicate Genotoxicity of the Soil Samples in SOS-ChromoTest

6.2.6.2 Experimental Procedure of SOS-ChromoTest

6.2.7 Extraction of Soil Samples for EROD Assay

6.2.8 EROD Assay

6.3 Results and Discussion

6.3.1 Seed Germination Test of the 12 Different Types of Land Use

6.3.2 Root Elongation Test of the 12 Different Types of Land Use
6.3.3 Correlation between Pollutant Concentrations, Seed Germination and Root Length ................................................................. 193
6.3.4 Mutagenicity of 12 Different Types of Land Use ....................... 196
6.3.5 Genotoxicities of 12 Different Types of Land Use ....................... 198
6.3.6 Ames and SOS Tests .............................................................. 200
6.3.7 Correlations Matrix of Pollutants with Mutagenic Potency and SOS Inducing Potency .............................................................. 201
6.3.8 EROD Assay Activity on 12 Different Types of Land Use .......... 203
6.3.9 Correlation of EROD Assay Activity with PCDD/Fs WHO TEQ on 12 Different Types of Land Use .................................................. 204
6.4 Conclusion .............................................................................. 206

Chapter 7 GENERAL CONCLUSION .................................................. 209

7.1 Concentrations of Pollutants after Changing Agricultural Land Use .... 209
  7.1.1 Non-Cancer Risk after Changing Agricultural Land Use .......... 210
  7.1.2 Cancer Risk after Changing Agricultural Land Use ............... 211
  7.1.3 Total, Bioaccessible and Bioavailable Pollutant Concentrations .... 211
  7.1.4 Response of Bioassay Test ....................................................... 212
  7.1.5 Summary of Pollutants levels, Response of Bioassays and Human Health Effect ................................................................. 213

7.2 Remediation of Current and Former Agricultural Soil .................... 213
  7.2.1 Soil Washing in Removing Heavy Metals ............................... 214
  7.2.2 Bioremediation of Organic Pollutants ................................. 215
  7.2.3 Phytoremediation to Reduce Bioaccessible and/or Bioavailable As... 216

7.3 Lacking Toxicity Values to Derive Reference Concentration for Non-Cancer Risk ................................................................. 217
  7.3.1 Limitation of Exposure Factors in the Present Study ............... 219
  7.3.2 New Recommended Values for Ingestion of Soil in the U.S. Exposure Handbook of 2009 ................................................................. 220
7.3.3 New Recommended Values for Inhalation of Soil Particles in the U.S. Exposure Handbook of 2009 ................................................................. 223

7.3.4 New Recommended Values for Dermal Contact of Soil in the U.S. Exposure Handbook of 2009 ................................................................. 225

7.4 Developing Soil Quality Guidelines for Protecting Agricultural Soil in HK ........................................................................................................ 228

7.4.1 Australian Guideline on the Investigation Levels for Soil ........ 231

7.4.2 Canadian Environmental Quality Guidelines (CCME, 2003) ....... 231

7.4.3 Environmental Quality Standard for Soils in China ................. 233

7.4.4 The New Dutch List .................................................................... 233

7.4.5 Sweden Soil Remediation Goals .................................................. 236

7.4.6 Contaminated Land Exposure Assessment Used in the UK ...... 239

7.4.7 Soil Screening Level of the USA .................................................. 239

7.4.8 Major Feature of Soil Quality Guidelines Recommended for Hong Kong ............................................................................................. 242

7.4.9 Principle of Development Soil Quality Guidelines .................. 244

7.4.10 Suggested Soil Quality Values for Agricultural soil in Hong Kong ................................................................................................. 246

7.4.11 Limitation of the Suggested Chemicals SQV for Agricultural Soil .... 251

References ................................................................................................. 253

Publications .............................................................................................. 275

Curriculum Vitae ....................................................................................... 277