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論文題目	Risk assessment and environmental capacity of organochlorine pesticide pollution from agricultural activities at Citarum Watershed, West Java, Indonesia (インドネシア、ジャワ島西部シタラム流域での農業活動による有機塩素系農薬汚染のリスクアセスメントと環境容量)		
(論文内容の要旨)			
Chapter 1 was the introduction of this dissertation, and provided study background. The problem issues were introduced and they were defined as bases of the main and sub objectives. The objectives are: (1) To obtain current status and level of OCP residue in the upper Citarum watershed area; (2) To obtain the risk analysis of population from different pathway of exposure such as fish, water and vegetables consumption; (3) To identify which area (subdistrict) has higher risk as a total risk from different pathway exposure; (4) To develop environmental compartment model and estimate the OCP level for each environmental compartment which will be used to calculate the environmental and human risk level; and (5) To estimate environmental capacity based on several scenarios by using the model output to reduce the risk of OCP from agricultural activities in the study site upper. In addition, the study site were summarized through literature review with general introduction. Chapter 2 presented the results of the investigation of the occurrence and level of OCPs in water, sediment and soil samples from the study site. Moreover new approaches of OCP analysis in soil samples by compiling three methods were developed, which are Supercritical Fluid Extraction (SFE) as extraction method, Solid Phase Micro-Extraction (SPME) as absorption, and GCMS as OCP analysis. The levels of OCPs in water, sediment, and soil samples were compared with the values in other countries report. Chapter 3 presented the results of the investigations of the OCPs occurrence and level in ground water samples collected from community water well and bore well. The comparison of OCP level with Indonesia drinking water standards and similar study from various countries is explained. The calculation of pollution index (PI), estimation of sub population exposure through drinking water consumption and dermal exposure were discussed in this chapter. Moreover its risk analyses on human health based on non-carcinogenic and carcinogenic effects were conducted by calculating Hazard Quotient and Cancer Risk. Chapter 4 presented the results of the investigations of the OCP residue in edible fish collected from Citarum River and cultivated fish in the study site. Fish consumption behavior based on the questionnaire survey of sub population was investigated to estimate daily fish consumption. The human risk of OCPs exposure on the local community who consume fish from Citarum watershed was evaluated based on various guidelines provided by different international organizations. Chapter 5 presented the results of the investigations of the OCP residue in vegetables collected from dry farming area, and it was discussed and compared with the maximum residue limit in Indonesia. The estimated daily intake (EDI) was determined based on vegetables consumption in West Java. The population risk analysis based on various guidelines proposed by different organization was determined. Chapter 6 discussed the farmer behavior on pesticide spraying on Citarum Watershed area. The data were collected from questionnaire survey and statistically analyzed by using SPSS ver. 11. The result was used as input parameter for environmental compartment model.			

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In Chapter 7, an environmental compartment model was developed based on fugacity approach. Some parameter was obtained from geographical condition and literature review. To estimate OCP input, questionnaire survey was conducted to get relevant information related with OCP application behavior by farmer. Model was validated by current OCP level in each compartment. In addition, several scenarios were applied and evaluated to decrease the risk of OCPs. In Chapter 8, the environmental capacity of study site was also calculated using the simulation model. The environmental capacity of each sub basin was calculated based on several scenarios of population consumption behaviors. Chapter 9, the last chapter, summarized scopes and concluded the all chapters. Recommendation and suggestions for government, especially for West Java Environmental Agency, was provided. Moreover, scope of further research was defined.			

(論文審査の結果の要旨)

本論文は、インドネシア、ジャワ島西部シタラム流域での有機塩素系農薬汚染の実態を調査し、そのリスク評価を行って、付近住民のリスクレベルを明らかにするとともに、流域圏における農薬使用量の環境容量という概念を確立することで、対象流域における農薬の適正使用量を提案したものである。得られた主な成果は以下のとおりである。

1. 環境や測定作業への負荷の小さい土壌中有機塩素系農薬濃度の分析法として、CO₂超臨界流体抽出法 (SFE)、マイクロ固相抽出法 (SPME)、ガスクロマトグラフ質量分析法 (GCMS) を組み合わせた方法を開発し、その最適な操作条件を明らかにした。

2. 河川水、井戸水、底質、土壌、魚類、野菜など様々な媒体中における有機塩素系農薬濃度を測定し、すでに使用が禁止されている DDT などの農薬も含め、各媒体から多くの農薬が検出されること、そして、いくつかの農薬についてはインドネシア政府や米国環境保護庁 (USEPA) の非発がん性影響、および発がん性影響に基づく濃度基準を超えていることを明らかにした。

3. 対象流域における農薬の挙動を表すモデルを作成し、その有効性を実データと比較することで検証した結果、一桁以内の誤差でおおよその濃度をシミュレートすることが可能であることを示した。このシミュレーションモデルを使用して、付近住民の許容リスクに対応する流域内での農薬使用量を、農薬の流域内環境容量として示して管理する方法を提案し、シタラム流域での許容農薬使用量を示した。

以上のように本論文は、有機塩素系農薬の新たな測定法の確立、インドネシア、ジャワ島西部シタラム流域における農薬汚染への対応の必要性、農薬の挙動シミュレーションを用いて求める環境容量という概念を利用した農薬の使用量管理を行う方法を提案するものであり、流域を単位とした農薬汚染のリスク管理手法確立に大きく貢献するものであって、学術上、実際上寄与するところが少なくない。よって、本論文は博士 (工学) の学位論文として価値あるものと認める。また、平成 24 年 12 月 19 日、論文内容とそれに関連した事項について試問を行って、申請者が博士後期課程学位取得基準を満たしていることを確認し、合格と認めた。