

# Assessment and management of transfer of persistent organic pollutants from soil to outdoor reared animals

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## 1. Introduction

Foods of animal origin are well-known contributors of human exposure to POPs due to their lipophilicity. Soil ingestion represents in this context one of the main exposure pathways of outdoor reared animals as it acts as a POPs reservoir. In such rearing practices, animals may ingest daily considerable amounts of this matrix [1]. In this frame methodologies to evaluate POP transfer from soil to food of animal origin is crucially needed as well as implementing strategies to limit it when necessary. Therefore, the aim of the current study was to estimate the transfer of POPs into food of animal origin using i) summarizing published knowledge on POP transfer by a meta-analysis; ii) evaluate the transfer of the emerging pesticide chlordecone (CLD) using new data of an *in vivo* study. Finally, these outcomes are used to assess the risk and, if necessary, to manage using a remediation strategy to limit their transfer.

## 2. Materials and methods

Literature meta-analysis with 41 peer-reviewed articles reporting transfer of PCDD/Fs, PCBs, OCPs to food of animal origin such as milk, eggs, and edible tissues as liver, muscles and adipose fat were performed. Transfer into milk and eggs was quantified using the concept of transfer rate (TR) calculated in steady state conditions. The accumulation in body tissues was expressed as a bioconcentration factor (BCF) for body tissues. More details and equations for calculation TR and BCF were presented in our latest study [2].

Then, a laboratory study involving 24 laying hens exposed daily to chlordecone contaminated andosol (4.1 mg/kg soil corresponding to 18 µg/kg body weight daily) and nitisol (1.6 mg/kg soil corresponding to 7 µg/kg body weight daily). According to a half-life of 5-6 days [3], animals were exposed for 21 days to reach steady state and estimate CLD transfer to eggs and liver. To investigate the reducing of the transfer, andosol and nitisol were amended (2% mass basis) by two different activated carbons (ACs). New data of CLD transfer to eggs and liver were treated in the same way as in the previous meta-analysis.

## 3. Results and discussion

### 3.1 Transfer of PCDD/Fs and PCBs (literature synthesis)

Generally, most of the studied compounds were transferred in a notable manner to the studied food materials. In details, the most toxic compounds such as 2,3,7,8-TCDD (34% and 39%), 1,2,3,7,8-PeCDD (27% and 36%), 2,3,4,7,8-PeCDF (36% and 40%) were highly transferred into milk and eggs respectively. Dioxin-like PCBs were also shown as extremely transferred with up to 50% of TR for congeners 105, 114, 118, 153, 156, 157, 167, 180, 189 and up to 40% of TR for congeners 126, 148 and 169 in both milk and eggs.

Intermediate TRs into milk were demonstrated for HxCDDs (13-23%) and HxCDFs (11-20%) as well as TR into eggs for HpCDD/Fs (16-18%). In addition, the transfer of PCB congeners 28, 81 and 123 were observed to be similar into milk (9-22%). Nevertheless, hepta- and octachlorinated CDD/Fs but also congeners 52 and 101 of ndl-PCBs were transferred at less than 5% into milk. In eggs, only octachlorinated PCDD/Fs and these PCB congeners showed a relatively low transfer (< 7%).

Furthermore, bioaccumulation of PCDD/Fs and PCBs in meat of adult animals was observed to be higher than in rapidly growing animals. This tendency appeared especially when BCFs in liver, fat and muscles were compared. Indeed, comparing laying hens to broilers, mean BCFs found for PCDDs were: 52 ±19 vs 14±5,

14±6 vs 2±0,9, 11±6 vs 1.5±0,6 respectively for liver, fat and muscles. Moreover, mean BCFs in adipose tissue of laying hens and broilers were 11 vs 4 and 10 vs 3, respectively for PCB congeners 126 and 169.

### 3.2. Transfer of OCPs into food

Generally, much less data were available in the literature to investigate OCP transfer into food of animal origin. Nevertheless, literature synthesis showed that TRs of DDTs and HCHs to chicken eggs were up to 58% and up to 32% respectively. Although DDT congeners were in general highly transferred, alpha or gamma HCH were reported to be transferred at a lesser extent. These two groups of pesticides could also accumulate in similar extent in the chicken gizzard (BCF 17 and 5), liver (BCF 15 and 16) and muscle (BCF 3 and 2).

In absence of existing knowledge on chlordecone transfer, the latest has been studied by exposure of laying hens. These birds showed very high TRs to eggs when exposed to CLD contaminated andosol or nitisol with respectively 78% and 65% (figure 1), as well as BCFs in liver of 6 and 2 (figure 2). Another study on ducks allow to calculate a BCF in liver of 37 [4]. Unfortunately, missing data in this study did not allow to calculate TR into eggs. The much higher BCF in their liver in comparison to our hen experiment may be explained by the low productivity of these ducks, and by consequence a low excretion of chlordecone.

### 3.3 Risk assessment and strategies to reduce POP transfer

These approaches allow to predict the concentrations of POPs, which would respect the MRLs in food of animal origin, and by consequence would allow to derive safe levels in soil to sustain animal rearing systems in exposed areas. In case of moderate overpassing, a strategy to reduce the transfer of POPs to animals may be implemented like using sequestration materials such as ACs. In the chlordecone context, even a relatively low CLD concentrations in soil may lead to contaminations close to MRLs in eggs. In such a frame, the studied amendment of contaminated soils allowed to decrease the transfer of CLD to chicken eggs from 65% to 45% (nitisol) and from 78% to 52% (andosol). In addition, BCF of CLD to liver reduced also from 2,4 to 1,5 (nitisol) and from 6 to 4 (andosol).

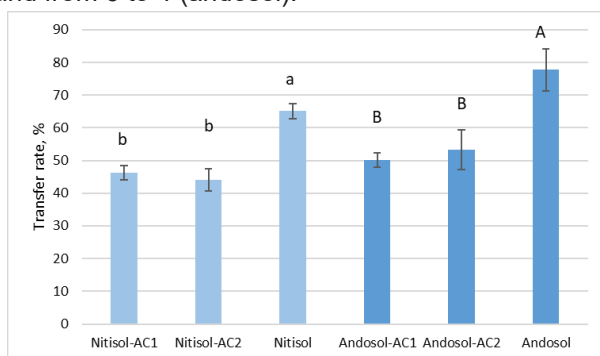


Figure 1 – Transfer rates of CLD to chicken eggs

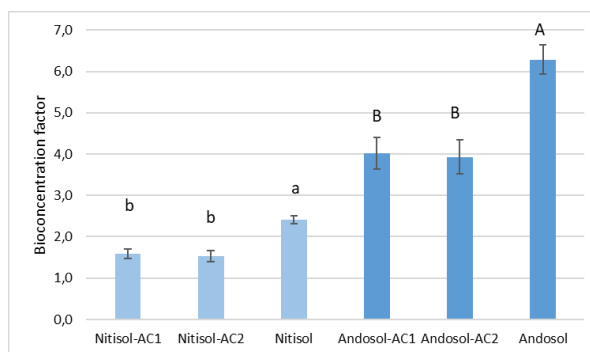


Figure 2 – Bioconcentration factors of CLD to chicken liver

## 4. Conclusions

POPs are generally highly transferred in food producing animals when they are raised on contaminated soils. Specific methodologies as TRs and BCFs allow to quantify and ranking risk focusing on food safety providing a relevant assessment. In this frame, it allows to derive safe levels in soil in order to sustain animal rearing practices in contaminated areas. When a management strategy is needed, an amendment of contaminated soils with sequestration materials like ACs may be investigated to reduce this POP transfer.

## 5. References

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