ATMOSPHERIC BURDEN OF ORGANOCHLORINE PESTICIDES (OCPs) IN GHANA

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Introduction

Organochlorine pesticides are chlorinated hydrocarbons that were previously applied to control insects and pests for agricultural and medical purposes. Most of the members in this group are now listed and regulated as POPs under the Stockholm Convention [1]. These chemicals are persistent, toxic, bioaccumulative, undergo long range transport and a prime source of environmental contamination. Although most OCPs are banned in Ghana, there are concerns that some may still be getting into the country through unofficial channels, such that there may be illegal application problems [2]. In this study, we investigated the atmospheric burden of OCPs in Ghana and gave a first account of the spatial resolution of these pollutants across the country.

Methodology

Sampling

Polyurethane foam (PUF) disk passive air samplers (PAS) were deployed across Ghana at 13 sites for 8 continuous weeks, between May and July 2010 (**Figure 1**). At the end of deployment in Ghana, PUF disks were harvested in air-tight package for the security from photo-exposure and returned to the National Institute for Agro-Environmental Sciences (NIAES), Tsukuba, Japan, for chemical analysis.

Chemical analysis

Harvested PUFs were soxhlet extracted with acetone for approximately 12 hours, and the extracts were concentrated, treated in clean-up then analyzed for 25 OCPs: hexachlorobenzene (HCB), *α*-, *β*-, *γ*- and *δ*-hexachlorocyclohexanes (HCHs), heptachlor, heptachlor epoxide, *trans*-chlordane, *cis*-chlordane, *trans*-nonachlor, *cis*-nonachlor, oxychlordane, *p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDD, *o,p'*-DDD, *p,p'*-DDE, *o,p'*-DDE, aldrin, dieldrin, endrin, mirex, endosulfan I, endosulfan II and endosulfan sulfate – using high resolution gas chromatography / high resolution mass spectrometry (HRGC/HRMS) (Auto Spec Ultima-Micromass).

Data conversion

The necessary conversion of data was made applying a sampling rate of 3.5 m^3/day [3].

Results and discussion

HCB

HCB air levels were fairly consistent among sites and ranged between 18.3 and 28.1 pg/m^3 (mean = 23.6 ± 0.8 pg/m^3) (**Figure 1**). HCB is structurally simple, hence, arises sometimes as impurity in other OCP products. It may also be generated as combustion byproduct. As HCB concentrations were similar between agricultural and non-agricultural sites, we presume the inputs were not necessarily from technical HCB but probably due to a common source factor like combustion.

HCHs

Air levels of *γ*-HCH constituted one to two orders of magnitude greater than the other isomers at all sites (**Figure 2**). As a pesticide, HCH was initially formulated as a technical mixture of *α*-, *β*- and *γ*-HCHs. It later became clear that *α*- and *β*- HCHs were less effective as insecticide and more toxic to non-target organisms than *γ*-HCH. Thus, manufacturers started to purify technical mixture HCH to produce lindane (product that contained only *γ*-HCH). Therefore, the high content of *γ*-HCH and little amount of the other isomers meant that mostly lindane, and not technical mixture HCH, was applied in Ghana.

Heptachlor

The average level of heptachlor in air (33.5 ± 11.2 pg/m^3) far exceeded its metabolite, heptachlor epoxide (0.8 ± 0.1 pg/m^3). Heptachlor epoxide is more likely to be found in the environment if heptachlor was applied long ago.

Therefore, the greater content of heptachlor over its metabolite suggests relatively fresh applications of this pesticide. Contamination from heptachlor was comparatively high in northern Ghana, implying that heptachlor may have been selectively applied in this region of Ghana (**Figure 1**).

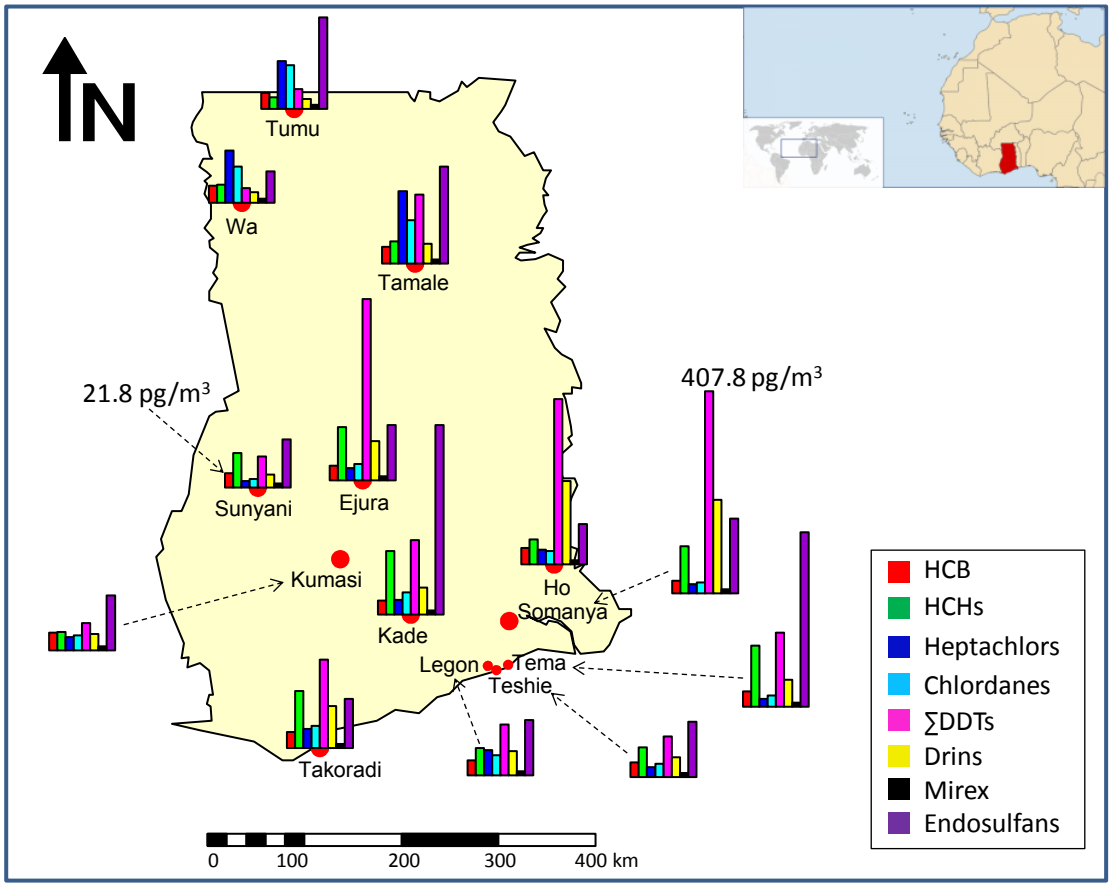

Figure 1. Sampling sites and spatial distribution of atmospheric OCPs in Ghana

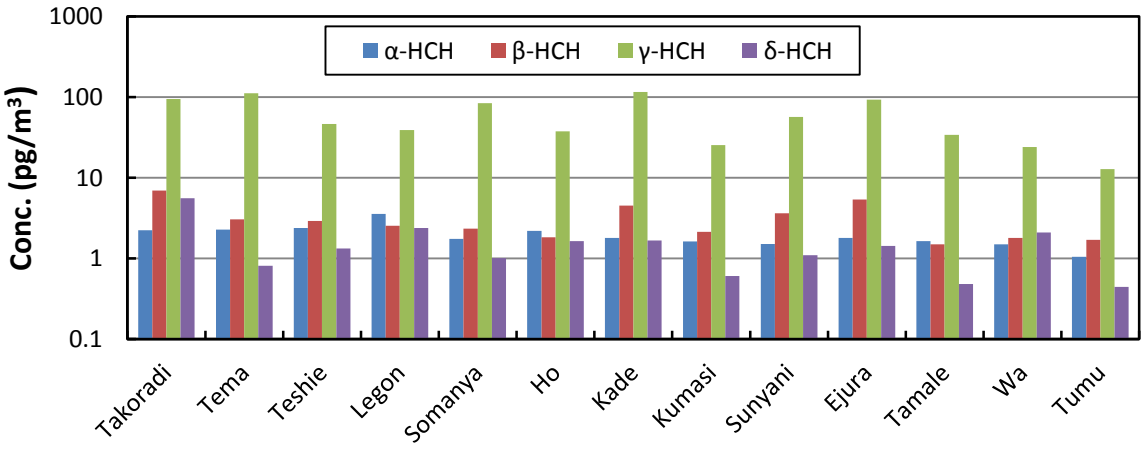

Figure 2. Air levels of HCH isomers at various sites in Ghana

Chlordanes

Air levels of ∑chlordane (sum of *trans*-chlordane, *cis*-chlordane, *trans*-nonachlor, *cis*-nonachlor and oxychlordane) were also comparatively greater in northern Ghana (**Figure 3**). *Trans*-chlordane was generally the most prevalent isomer.

DDTs

Mean ∑DDT (sum of all the isomers) was 156 ± 36 pg/m^3. ∑DDT was comparatively high at Somanya, Ho and Ejura (agricultural sites) (**Figure 1**). Two different DDT isomer patterns can be identified in **Figure 4**. One pattern was consistent among sites in the mid to northern belt of Ghana (Kumasi, Sunyani, Ejura, Tamale, Wa and Tumu) and non-agricultural sites in the southern belt (Takoradi, Teshie and Legon). The other pattern was consistent among the remaining sites in the southern belt – Somanya, Ho and Kade – all agricultural sites, each of which has a *p,p'*-DDT/*p,p'*-DDE ratio greater than one. This suggests relatively recent encounters with DDT at Somanya, Ho and Kade. A striking feature of the DDT isomer profile in Ghana was the relatively high content in *o,p'*-DDT, a nearly inactive isomer present as contaminant in technical DDT.

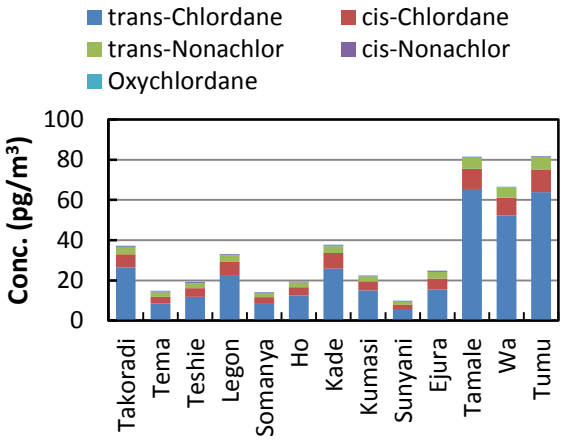

Figure 3. Chlordane isomer concentrations in air across Ghana

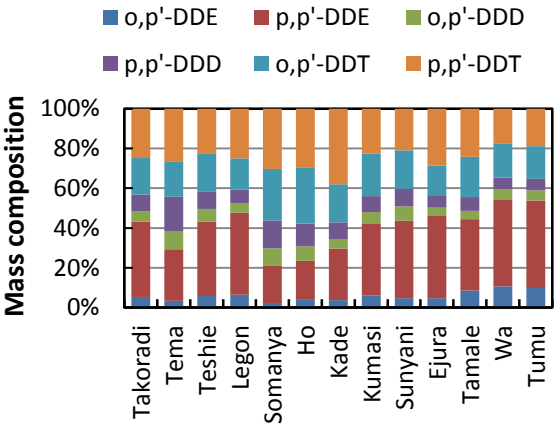

Figure 4. Atmospheric DDT isomer profile in Ghana

Drins

The average drin concentrations were as follow: aldrin (1.0 ± 0.2 pg/m^3), dieldrin (55.2 ± 13.7 pg/m^3) and endrin (3.1 ± 0.6 pg/m^3). Thus, increased contamination was observed for dieldrin in this group. Somanya and Ho, both agricultural sites, were the areas with highest concentrations of drins (**Figure 1**).

Mirex

Mirex concentration was consistently low across the country at an average of 0.2 ± 0.01 pg/m^3 (**Figure 1**). This might represent background levels as mirex is not known to have been used in Ghana.

Endosulfans

Mean ∑endosulfan (sum of endosulfan I, endosulfan II and endosulfan sulfate) was 153 ± 28 pg/m^3. Endosulfans were only recently banned in Ghana, having been intensively applied for several years. Therefore, its high content in air might reflect recent usage. Mean concentrations of endosulfan I, endosulfan II and endosulfan sulfate were 109 ± 21, 33 ± 6 and 3.6 ± 0.9 pg/m^3, respectively. Thus, among the members in this group, endosulfan I posed the greatest problem. The highest levels of ∑endosulfan were recorded at Kade and Tema. Kade is an agricultural site where endosulfans were previously applied. Tema, however, is an industrial site. The source of high levels of endosulfans at Tema is presently unclear.

Conclusion

The spatial resolution of air OCPs in Ghana revealed area specific variation in past applications of some OCPs. For instance, it emerged that heptachlor and chlordanes were applied mostly in northern Ghana, while HCHs, DDT, and the drins were more prominent in mid to southern Ghana. The endosulfans were however prominent across the country. DDT and endosulfans constituted the highest burden of ambient OCPs in Ghana. We suspect that the contaminations from DDT, endosulfans and heptachlor were relatively recent in some parts of Ghana.

Acknowledgements

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