

GLOBAL MONITORING PLAN

FOR PERSISTENT ORGANIC POLLUTANTS

UNDER THE STOCKHOLM CONVENTION ARTICLE 16 ON EFFECTIVENESS EVALUATION

FIRST REGIONAL MONITORING DRAFT REPORT

AFRICA REGION



15TH MARCH 2009

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PREFACE

Persistent organic pollutants (POPs) are a group of chemicals that are widely used in agricultural and industrial practices, as well as unintentionally released from many anthropogenic activities around the globe. POPs are characterized by *persistence* – the ability to resist degradation in various media (air, water, sediments, and organisms) for months and even decades; *bio-accumulation* - the ability to accumulate in living tissues at levels higher than those in the surrounding environment; and *potential for long range transport* – the potential to travel great distances from the source of release through various media (air, water, and migratory species). Specific effects of POPs can include cancer, allergies and hypersensitivity, damage to the central and peripheral nervous systems, reproductive disorders, and disruption of the immune system. Some POPs are also considered to be endocrine disrupters, which, by altering the hormonal system, can damage the reproductive and immune systems of exposed individuals as well as their offspring. The ability of these toxic compounds to be transported to isolated areas of the globe, such as the Arctic, and to bioaccumulate in food webs, has raised concerns for the health of humans and the environment, particularly for indigenous people that rely on traditional diets of marine mammals and fish. The African continent is not spared from the toxic effects of these POPs. Human and wildlife are both exposed to POPs previously applied in agriculture and industrial activities.

The transboundary movement of the compounds and the international scope of their manufacture, use and unintentional releases, and their long distance transport to impacted populations led to the adoption of the Stockholm Convention on Persistent Organic Pollutants in May 2001 to “*protect human health and the environment from persistent organic pollutants by reducing or eliminating releases to the environment*”. Substances presently being addressed under the Convention are aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, PCBs PCDDs/PCDFs and toxaphene. The Convention includes a procedure to add further substances to it.

The Convention calls for the reduction or elimination of releases of persistent organic pollutants, which should translate into reduced environment levels over time. The Convention is unique in that, by its article 16, the Convention had set for itself the task to evaluate its effectiveness and to ensure the Convention goals were being met. In this respect, the Convention places responsibility on the regions to produce a monitoring report, and all these reports put together will be compiled in a global monitoring report.

Article 16 of the Stockholm Convention stipulates that the Conference of the Parties shall evaluate the effectiveness of the Convention four years after its date of entry into force. The effectiveness of the Convention shall be evaluated on the basis of available scientific, environmental, technical and economic information, including:

- Reports on monitoring of environmental levels
- National reports submitted pursuant to Article 15
- Non-compliance information provided pursuant to Article 17.

An important component of effectiveness evaluation is the development of a global monitoring plan providing a harmonized organizational framework for the collection of comparable monitoring data or information on the presence of the persistent organic pollutants from all regions, in order to identify changes in levels over time, as well as to provide information on their regional and global environmental transport. The first report for the effectiveness evaluation will be presented at the fourth meeting of the Conference of the Parties in May 2009 and will serve as a baseline for further evaluations.

The global monitoring plan is being implemented in all five United Nations Regions. This regional monitoring report presents the findings and describes the baseline levels of POPs in the African region. Despite its shortcomings in terms of hazardous chemicals management and awareness, Africa is making slow but sure steps to achieve the objectives that are laid down in the Stockholm Convention. Most African

countries through their NIPs (within the framework of the Stockholm Convention) have elaborated plans of action to phase out or reduce POPs. It is indeed fortunate that these NIPs and Action Plans have gained recognition from NEPAD and therefore the African Union, and is an indication of the seriousness of Africa's commitment to control hazardous chemicals. We are confident that the Africa regional monitoring report will meet the objectives laid down by the Project and will contribute significantly to the overall GMP report.

ABBREVIATIONS AND ACRONYMS

ACP	Arctic Contamination Potential
ADI	Acceptable Daily Intake
ALRT	Atmospheric Long Range Transport
AMAP	Arctic Monitoring and Assessment Program
ANCAP	African Network for Chemical Analyses of Pesticides
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
APEs	Alkylphenol Ethoxylates
ASP	Africa Stockpile Program
AU	African Union
AUC	African Union Commission
BCF	Bioconcentration Factor
BHC	Benzenhexachloride
BPH	Benzo(a)pyrene oxidation
CEE	Central and Eastern Europe
CEN-SAD	Community of Sahelo-Saharan States
CEP	Caspian Environment Program
CERES	Centre of Research and Ecotoxicology of the Sahel (<i>Laboratory in Senegal responsible for analyses of residues in environmental media and food</i>)
CILSS	Comité Inter Etats de Lutte contre la Sécheresse dans le Sahel (Sahel Drought Control Committee)
CIS	Commonwealth of Independent States
CIEN	Chemical Information Exchange Network
COMESA	Common Market for Eastern and Southern Africa
CRM	Certified Reference Material
COP	Conference of the Parties
CTD	Characteristic Travel Distance
CV	Coefficient of Variation
DDD	Metabolites of DDT
DDE	Metabolites of DDT
DDT	Dichlorodiphenyltrichloroethane
DTIE	Division of Technology, Industry and Economy
DLPCBs	Dioxin-like PCBs
EAC	East African Community
EADN	East African Development Network
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
EDCs	Endocrine Disrupting Chemicals
EMAN	Ecological Monitoring and Assessment Network
EMEP	Co-operative Program for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe
EPER	European Pollutant Emission Register
ERL	Effects Range Low
ERM	Effects Range Median
EROD	7-ethoxyresorufin-O-deethylase
EUSES	European Union System for the Evaluation of Substances

FAO	Food and Agriculture Organisation (of the United Nations)
FERTIMEX	Fertilizantes Mexicanos
GAPS	Global Atmospheric Passive Sampling Survey
GEF	Global Environment Facility
GEMS	Global Environment Monitoring System
GDP	Gross Domestic Product
GHS	Global Harmonised System
GLBTS	Great Lakes Bi-national Toxics Strategy
GMP	Global Monitoring Plan
HCB	Hexachlorobenzene
HELCOM	Helsinki Commission/The Baltic Marine Environment Protection Commission
HCHs	Hexachlorocyclohexanes
HIPS	High Impact Polystyrene
HPLC	High Performance Liquid Chromatography
HRGC	High Resolution Gas Chromatography (capillary column)
HRMS	High Resolution Mass Spectrometer
HV	High Volume
HxBB	Hexabromobiphenyl
IADN	Integrated Atmospheric Deposition Network
IAEA	Inter Atomic Energy Agency
IARC	International Agency for Research on Cancer
ICES	International Council for the Exploration of the Sea
IFCS	Intergovernmental Forum on Chemical Safety
IMO	International Maritime Organisation
INSPQ	Centre de Toxicologie du Québec
INFOCAP	Information Exchange Network on Capacity Building for the Sound Management of Chemicals
IPPC	Integrated Pollution Prevention and Control
I-TEQ	International Toxicity Equivalence Quantity
KA_w	Air/Water Partition Coefficient
K_{oA}	Octanol/Air Partition Coefficient
K_{ow}	Octanol/Water Partition Coefficient
LC ₅₀	Median Lethal Concentration
LD ₅₀	Median Lethal Dose
LOAEL	Lowest Observable Adverse Effect Level
LOD	Limit of Detection
LOQ	Limit of Quantification
LRT	Long Range Transport
LRTAP	Long Range Transport Air Pollutants
L RTP	Long Range Transport Potential
MDL	Minimum Detectable Level
MEDPOL	Mediterranean Pollution Monitoring and Research Program
MEAs	Multi Lateral Environmental Agreements
MRL	Maximum Residue Limit
MSCE-East	Meteorological Synthesizing Centre-East
NA	Not Available
NAFTA	North American Free Trade Agreement
NARAPs	North American Regional Action Plans

NEPAD	New Partnership for African Development
ND	Not detected
NGOs	Non-Governmental Organisations
NHATS	National Human Adipose Tissue Survey
NIP	National Implementation Plan
NIS	Newly Independent States
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observable Adverse Effect Level
NOEL	No Observable Effect Level
NRBP	Nairobi River Basin Project
NWT	Northwest Territories
OCs	Organochlorines
OCPs	Organochlorine Pesticides
OECD	Organisation for Economic Co-operation and Development
OPs	Organophosphates
OSPAR	Commission for the Protection of the Marine Environment of the North-East Atlantic
PAHs	Polycyclic aromatic hydrocarbons
PAS	Passive Air Sampler
PBDEs	Polybrominated diphenyl ethers
PCBs	Polychlorinated biphenyls
PCDDs	Polychlorinated dibenzo-p-dioxins
PCDFs	Polychlorinated dibenzofurans
PCP	Pentachlorophenol
PFOS	Perfluorooctane sulfonate
PIC	Prior Informed Consent
POPs	Persistent Organic Pollutants (group of twelve as defined in the Stockholm Convention 2001)
PRTRs	Pollutant Release and Transfer Registers
PTS	Persistent Toxic Substances
PUF	Polyurethane Foam
PVC	Polyvinylchloride
QA/QC	Quality Assurance and Quality Control Regimes
RCG	Regional Coordinating Group
REACH	Registration, Evaluation and Authorisation of Chemicals
REC	Regional Economic Community
RECETOX	Research Centre for Environmental Chemistry and Ecotoxicology
RENPAF	Regional Network on Pesticide Production in Asia and Pacific
ROGs	Regional Organization Groups for the Global Monitoring Plan
ROPME	Regional Organisation for the Protection of the Marine Environment
ROWA	Regional Organisation of West Asia
SADC	South African Development Cooperation
SAICM	Strategic Approach to International Chemicals Management
SCCPs	Short-chain chlorinated paraffins
SOP	Standard Operating Procedure
SPM	Suspended particulate matter
SPREP	South Pacific Regional Environment Program
T	Tonne
TBBPA	Tetrabromobisphenol A

TCDD	Tetrachlorodibenzo- <i>p</i> -dioxin
TEL	Tetraethyllead
TEQ	Toxicity Equivalents
TOMPS	Toxic Organic Micropollutants Survey
TPT	Triphenyltin
UMA	Union du Maghreb Arabe
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Program
UNIDO	United Nations Industrial Development Organisation
UNITAR	United Nations Institute for Training and Research
WFD	Water Framework Directive
WHO	World Health Organisation
WMO	World Meteorological Organization
XAD	Styrene/divinylbenzene-co-polymer Resin

GLOSSARY OF TERMS

Activity	Any Program or other activity or project that generates data or information on the levels of POPs in the environment or in humans that can contribute to the effectiveness evaluation under Article 16 of the Stockholm Convention Core matrices. These are the matrices identified by the Conference of the Parties to the Stockholm Convention at its second meeting as core for the first evaluation: A = ambient air; M = (human) mother's milk and / or B = human blood.
CTD	The characteristic travel distance defined as the "half-distance" for a substance present in a mobile phase.
I L-1	Instrumentation level capable of analysing PCDDs/PCDFs and dioxin-like PCB at ultra-trace concentrations: must be a high-resolution mass spectrometer in combination with a capillary column.
I L-2	Instrumentation level capable of analysing all POPs: (capillary column and a mass-selective detector).
I L-3	Instrumentation level capable of analysing all POPs without PCDD/PCDF and dioxin like PCB (capillary column and an electron capture detector).
I L-4	Instrumentation level not capable of doing congener-specific PCB analysis (no capillary column, no electron capture detector or mass selective detector).
Intercomparisons	Participation in national and international intercalibration activities such as ring-tests, laboratory performance testing schemes, etc.
LOD	Limit of detection. The lowest concentration at which a compound can be detected. It is defined as that corresponding to a signal three times the noise.
<LOD	Result below the limit of detection.
LOQ	Limit of quantification: The lowest concentration that can quantitatively be determined and is three times higher than LOD.
<LOQ	Result below limit of quantification. Compounds found at levels between LOD and LOQ can be reported as present, or possibly as being present at an estimated concentration, but in the latter case the result has to be clearly marked as being below LOQ.
MDL	Method detection limit: the MDL considers the whole method including sampling, sample treatment and instrumental analysis. It is determined by the background amounts on field blanks.
KR2 Grants	Japanese grants to developing countries on agriculture, including pesticides.
Roll Back Malaria Program	Program to contain or eradicate malaria through the use of medication and pyrethroid impregnated bed nets.
Phase I	Activities to support the Article 16 effectiveness evaluation that will be

conducted by the Conference of the Parties at its fourth meeting, information collected between 2000 and 2007 (also termed as the first evaluation).

EXECUTIVE SUMMARY

Introduction

Decision SC-3/19 established a Regional Organization Group (ROG), composed of six members for each of the five United Nations Regions to facilitate implementation of the global monitoring plan, and invited Parties to nominate members to those groups with expertise in monitoring and data evaluation. The main objectives of the regional organization groups were to define and implement the regional strategy for information gathering, including capacity building and establishment of strategic partnerships in order to fill the identified data gaps, and to prepare the regional monitoring report as a contribution to the first effectiveness evaluation report, to be presented to the Conference of the Parties at its fourth meeting in May 2009.

This report is the input of the African Region in the first GMP. Principally, it summarises the data collected from the monitoring programs within the region to record baseline concentrations of POPs in core media selected for the first evaluation namely ambient air and human milk. It also provides some limited information of data from other media (sediments, water, soil etc.) and finally gives cost-effective recommendations for the implementation of sustainable POPs monitoring activities to enable the Region contribute meaningfully to monitoring programs and future evaluations.

Overview of the African region

Africa is one of the largest United Nations regions with an area of 40,065,721 square miles and is divided into Northern Africa, Southern Africa, Eastern Africa, Western Africa, Central Africa and the Island States. The Region is characterized by six different climatic zones that have influence on the movement and distribution of POPs. In addition, except for large deserts in Northern and Southern Africa, the region faces challenges associated with hot and humid climatic conditions that promote growth of a myriad of pests and disease vectors. POPs have therefore been used in many sectors including agriculture, industry and public health to control pests and diseases. The key challenges related to POPs include: lack of knowledge and information on hazards, risks and safer alternatives; lack of legislation or enforcement measures; weakness of the technical infrastructure and shortage of qualified human resources. However, it is worth noting that some reliable capacity is present at national and regional levels in both the academic and institutional sectors. In such a context, the decision to implement the Convention's effectiveness evaluation presents a demanding challenge to the region. To participate in the first evaluation, the region relied exclusively on the technical and financial assistance opportunities provided by the Convention according to Articles 12 and 13 for the collection of comparable data on core media. It is worth noting however, that there is some reliable capacity in both the academic and institutional sectors at national and regional levels that, with capacity enhancement, would be able to contribute to future monitoring programmes.

Contributing/collaborating programmes

The Africa region collaborated with the following programmes and strategic partners to obtain data on core media: the MONET-Africa project coordinated by the Centre of Excellence in Environmental Chemistry and Ecotoxicology, Brno, Czech Republic (RECETOX), the Global Atmospheric Passive Sampling (GAPS) programme coordinated by Environment Canada for ambient air data, and the World Health Organization (WHO) for human milk data. The selected strategic partners do have consolidated expertise in their respective areas for sampling, analysis, and interpretation of results in accordance with the criteria

contained in the Implementation Plan for the First Effectiveness Evaluation. The implementation of the MONET Africa and WHO milk survey was facilitated by the coordination, technical assistance and financial support from the Stockholm Convention Secretariat, the UNEP Chemicals, and the GEF. Some academic and research institutions within the region provided data on other media and to a limited extent additional data on human milk, blood and ambient air.

Main findings

Baseline Levels of POPs in air

The available monitoring data for air provide indicative information about POPs levels in the region. Most of the data was provided by the strategic pilot activities established in 2008 and therefore their continuation will provide sufficient baseline upon which future evaluations can be drawn. GAPS data was collected from 2005 to 2006 but only in four countries: South Africa, Ghana, Egypt and Malawi. The MONET Africa pilot project was implemented in 2008 in the region in an attempt to bridge the existing huge spatial data gaps. 15 countries in the region participated in the MONET ambient air monitoring programme namely: Kenya, Mali, South Africa, Mauritius, Zambia, Ethiopia, Sudan, Egypt, Togo, Ghana, Nigeria, Congo Republic, Democratic Republic of Congo, Senegal and Tunisia. Sampling sites ranged from rural to urban background, and in a few countries to sites heavily affected by the industrial activities or obsolete pesticide stocks.

The monitoring data showed that ambient air in Africa was contaminated by POPs that are currently listed under the Convention. The air contamination by POP pesticides should be considered as an issue of concern since none of the selected countries had the full set of listed pesticides below the quantification limit. In some cases low metabolites to parent POP pesticide ratios revealed recent or current usage of persistent organic pollutant compounds. The levels of polychlorinated biphenyls (PCBs) measured in urban and industrial sites in the region were comparable to the ones measured at industrial sites in Europe. In addition, all sites were found to be contaminated by different types of PCDDs/Fs, the main sources being industrial activities and open burning processes. Several sites (Mt. Kenya in Kenya, Tombouctou in Mali, Molopo Nature Reserve or Barberspan in South Africa, Reduit in Mauritius) were found to be good candidates for future background monitoring on the continent.

Baseline Levels of POPs in human milk/blood

The available POPs monitoring data for human milk was obtained from Egypt for the samples submitted during the 3rd round of WHO milk survey and from Sudan for the samples submitted during the 4th round of milk survey. Additional data was to be obtained from UNEP/WHO milk survey, a supplementary data collection activity initiated in 2008, to fill the envisaged data gaps for the first effectiveness evaluation. The data provides indicative levels of POPs against which the changes in levels over time may be evaluated.

Baseline Levels of POPs in other media

Data on the levels of POPs in other media such as soil, water, sediments and food, were extracted from published research findings in the region. It is worth noting that there is lack of an organized monitoring programme with well established protocols for monitoring POPs in other media. Therefore, the available data provides indicative levels of POPs in the region and shows that all POPs under annexes A and B of the Convention do contaminate the ecosystems and the local population through these media, which should be an issue of concern throughout the region. The data also to a greater extent shows that the existing capacity for POPs analysis is mainly for POPs pesticides and PCBs. Therefore, with capacity

enhancement within the framework of a regionally harmonized monitoring program, the regional and national institutions can contribute to production of GMP data.

Long-range transport of POPs

The absence of sufficiently long-term regional monitoring programmes on persistent organic pollutants did not allow for a comprehensive investigation and evaluation of long-range transport and temporal trends of persistent organic pollutants in the region. This is due to the fact that most of the data was produced within the 6 months supplementary data collection activities established in 2008. However, preliminary analysis of back trajectories was conducted using the air data collected by the MONET Africa monitoring programme in 2008.

Data gaps

The available core media POPs monitoring data was mainly provided through the strategic data collection activities established in 2008. Quantitative comparisons of the levels of POPs across countries were very difficult, because of the lack of adequate data and their completeness, and the short period covered for the established supplementary data collection activities. Generally, the region lacks long-term established programs with good regional spatial representation to comprehensively address the time trend in concentration, long-range transport and spatial distribution of POPs. In this regard, the following were identified as key data gaps: inadequate milk data for some sub-regions; lack of systematic monitoring of POPs in the core media (ambient air and human milk or blood) is taking place; lack of data on PCDD/PCDF are available; and very limited data on PCBs.

Capacity building needs

In order to address the existing data gaps, capacity building for POPs monitoring remains a high priority for most countries and the region at large. These include: building human capacity to analyse and manage POPs, support for dedicated regional laboratories with necessary high resolution equipment for analysis of all POPs compounds; support for regional approach, to POPs monitoring by establishing regional programmes with standardized protocols for determination of POPs in core media and non core media; provision of basic consumables and equipment to national laboratories to support their involvement in regional programmes; involvement of national regional institutions in proficiency testing and upgrading their performances in POPs analysis; promoting of regional data sharing and storage; support sample banking for future evaluations; and support for regional communication among the regional organization groups and focal points through Chemical Information Exchange Network (CIEN) and similar efforts.

Future monitoring programmes

Future evaluations would benefit from 1) maintaining on-going monitoring programmes to support generation of baseline data in the region, 2) maintaining and enhancing regional coverage of the established strategic programmes to provide additional data in the core media, 3) continued monitoring to produce comparable data to support the assessment of trends and levels determined in the core media, as well as at least one additional medium of regional priority, 4) incorporation of candidate persistent organic pollutants into the monitoring programmes, 5) enhancing participation of regional institutions and laboratories through the analysis of parallel samples, 6) facilitation of inter-laboratory calibration and training activities, and 7) establishing a regional specimen bank and database for the core media.

Conclusions

- 1) Due to lack of established POPs monitoring programmes with adequate regional representation, Africa exclusively depended on partnerships and strategic activities established in 2008 such as GAPS, RECETOX and WHO to produce regional POPs data for ambient air and human milk;
- 2) There is limited analytical capacity characterised by weakness of analytical infrastructure among the regional institutions and laboratories to analyse POPs with most only capable of analysing a few POP pesticides and PCBs. The analytical capacity to measure PCDDs/PCDFs is completely missing.
- 3) There is some human capacity in some countries in the region, to measure POPs in core media, and with additional capacity enhancement can participate in monitoring programme.
- 4) Most of the POPs data in other matrices was obtained from published literature from national research activities due to lack of established monitoring programmes,
- 5) There are several identified institutions in the region that conduct research on POPs but have weak analytical, data handling, storage and dissemination capacities;
- 6) The available POPs data is inadequate in most sub-regions due to limited number of countries participating in the established monitoring activities;
- 7) The region has relatively poor communication network that contributes to delays the judicious implementation of the GMP activities;
- 8) There is limited coordination among the regional institutions dealing with POPs and other related Multilateral Environmental Agreements such as the Basel, Rotterdam and Basel conventions;
- 9) Most African countries are Parties to the Stockholm Convention and many have elaborated and submitted their National Implementation Plans to the COP, but there is still limited coordination and collaborative activities at national and regional levels;
- 10) Some countries provided instructive data on the levels of POP pesticides in water, sediments, soil and food stuff indicating the existing expertise within the region, which needs to be strengthened if Africa has to participate meaningfully in the future evaluations.

Recommendations

A cost-effective approach to future evaluations should include the following:

- 1) Providing additional support to maintain established strategic GMP monitoring activities such as ambient air monitoring and human milk survey to enable continued production of adequate POPs data in core media to enable evaluation of temporal trends and long range transport;
- 2) Developing the GEF regional proposals and seeking technical assistance to boost the analytical capacity of the regional institutions to produce high quality and comparable POPs data to GMP;
- 3) Enhancing the human capacities of regional institutions and laboratories network based on harmonized POPs monitoring protocols for each core media to facilitate the production of continent-wide comparable data;
- 4) Establishing regional monitoring programme to produce comparable data in at least one regional matrix of priority to support the data obtained from core media;
- 5) Strengthening the capacity of identified national and regional laboratories to conduct POP analyses through GEF capacity building programs to support regional training in POPs analysis and data handling as well as to support the monitoring programmes;
- 6) Widening the participation in POPs monitoring programmes to cover more countries and strengthen partnership and collaboration in GMP and other related activities in the region through bilateral or multilateral partnerships through Projects such as GEF and the EC-ACP projects on Capacity Building;

- 7) Enhancing the coverage of regional information exchange through UNEP chemical activities such as CIEN to sensitize government officials such as the Ministers of Environment, Finance and other relevant ministries on the importance of POPs monitoring activities;
- 8) Strengthening the capacity of existing regional structures such as the Stockholm Convention/Basel Regional Centres and others such as NEPAD;
- 9) Forming National Task Forces on GMP, comprising of Stockholm Convention Focal Points, national contacts and the local stakeholders to oversee and coordinate activities related to GMP at national levels;
- 10) Mainstreaming of the chemical management activities such as POPs monitoring into the regional and national development agenda.

1. INTRODUCTION

1.1 BACKGROUND

The Stockholm Convention on Persistent Organic Pollutants (POPs) was negotiated from June 1998 to December 2000, adopted as an international legally binding instrument on 23 May 2001 and entered into force on 17 May 2004. The aim of the Stockholm Convention is to protect human health and the environment from the adverse effects of POPs (Article 1), by reducing or eliminating their releases to the environment. As of 3rd August 2008, 50 African countries were Parties or Signatories to the Convention (Annex A Table A 1).

Persistent Organic Pollutants (POPs) are a group of chemicals that pose serious risk to human health and the environment. They persist for long periods and often travel long distances from their source of production. They accumulate in living species, becoming more concentrated in fatty tissues as they move up the food chain.

POPs possess toxic properties, resist degradation, bio-accumulate and are transported through air, water and migratory birds and animal species across international boundaries, being subsequently deposited in distant places where they accumulate in terrestrial and aquatic ecosystems. Studies on wildlife, and to a certain extent on humans, have shown that exposure to these chemicals may result in birth defects, cancers, immunological and reproductive disorders, and a diminishing of intelligence. These toxic contaminants can be passed on to future generations, for example, through breast milk.

The increase in use of these chemicals in developing countries and particularly in Africa is of a major concern because of the lack of capacity and infrastructure to ensure their safe use and disposal.

The Stockholm Convention represents a major step towards global protection of human health and the environment from the dangers resulting from the use of POPs. The Convention aims at controlling POPs, with the view of phasing them out. The main objective of the Stockholm Convention on POPs is to protect human health and the environment from persistent organic pollutants. Twelve POPs are initially identified and listed in annexes A, B, and C of the Stockholm Convention (Annex A Table A 2 to A 4) and these are the POPs that are targeted for regulatory action (UNEP, 2001).

One of the requirements of the Convention is that Parties should prepare and implement a phase out plan of action of POPs through a GEF Funded Project. The Implementation Plan outlines all aspects of POP management, including general sensitisation mechanisms and strategies to dispose of waste. The overall objective of the NIP is to develop a national framework with a view to protect human health and the environment from the effects of POPs by preparing the ground for effective implementation of the Convention and strengthening of the country's national capacity to manage chemicals in general, and POPs in particular.

As POPs pose a major concern to mankind, Parties to the Convention agreed that there was need to monitor their presence and removal from the environment and human system through a measuring mechanism to ensure that the objective of reduction and elimination is attained.

This decision to monitor is contained in Article 16 of the Convention which provides for an effective evaluation of the phasing out process four years after the date of entry into force of the Convention, and periodically thereafter at intervals to be decided by the Conference of the Parties (COP).

1.2 OBJECTIVES OF ARTICLE 16 OF THE STOCKHOLM CONVENTION

The main element in the effectiveness evaluation is the development and implementation of arrangements to provide globally comparable monitoring data on the presence of the chemicals listed in Annexes A, B and C of the Stockholm Convention, as well as information on their regional and global long range transport. Such arrangements should be implemented on a regional basis when appropriate. Therefore, the objectives of the article are:

1. To provide a mechanism to evaluate the process of phasing out of POPs;
2. To evaluate the effectiveness of the mechanism;
3. To provide data on the presence of the targeted POPs;
4. To provide information on the regional and global transport of these POPs.

1.3. OBJECTIVES OF THE POPs GLOBAL MONITORING PLAN (GMP)

To facilitate the evaluation and monitoring process, UNEP Chemicals developed a POPs Global Monitoring Program (GMP). The main objectives of the Program are:

- a) To evaluate actual reduction or elimination of POPs in response to Articles 3 and 5 of the Convention
- b) To provide a harmonized organizational framework for the collection of comparable monitoring data on the presence of the POPs listed in Annexes A, B and C of the Convention
- c) To provide information on the regional and global environmental transport of these POPs
- d) To detect the trends in levels of POPs exposure in human
- e) To build the capacity of Africans to undertake such studies and implement POP related programs
- f) To assist with regional capacity building in developing countries

The COP also decided to establish a provisional *ad hoc* technical working group to coordinate and oversee implementation of the GMP. The technical working group was requested, among other things, to develop an implementation plan to fulfill the minimum requirements for the first Effectiveness Evaluation, using comparable data from regional monitoring programs and data provided by Parties, and to present the data on a regional basis to be used as a baseline.

Parties were requested to nominate members to those technical groups with expertise in monitoring and data evaluation and decided that each regional organization group should comprise of six members. The main objectives of the regional organization group were to define and implement the regional strategy for information gathering, including capacity building, and to prepare the regional monitoring report for the first Effectiveness Evaluation to be performed by the Conference of the Parties in May 2009.

The major output to be produced by the regional organization group is the regional monitoring report that summarises the results of monitoring programs within their region, and that records baseline concentration in the environment and human milk or blood, against which temporal trends can be established. Another function of the report is to facilitate communication on contaminant issues between regions and assist in addressing gaps in the global program. The regional reports comprise an element of the reporting to the Conference of the Parties and provide an important link between the field sampling programs and the evaluation of the effectiveness of the Stockholm Convention.

The COP also agreed that the minimum requirements for the first evaluation will be that:

- a) The first monitoring report will provide baselines for further evaluations;
- b) Such comparable and representative core data should be obtained from all five regions;

- c) Guidance should be provided on standardization;
- d) Strategic arrangements and partnerships shall be established, particularly with the health and the agriculture sectors;
- e) Reports are prepared for the Conference of the Parties summarizing and presenting the data as per an appropriate agreed format.
- f) Air monitoring and human exposure through human breast milk or human blood would be used as core data.

For future evaluations, the Conference of the Parties also made the decision to use data from other media such as biota, water, soil, and sediments.

The choice of the use of human milk is based on the fact that human milk is an attractive medium because it is non-invasive and relatively large volumes of samples can be easily collected in a more or less standardized manner. However, it has disadvantages in the sense that only one gender constituting a limited age group is monitored. On the other hand, although maternal blood is an invasive procedure, its choice as a favorable matrix could be due to existing activities, customs and available infrastructure.

The monitoring Programs and activities are categorized into the following groups:

Group 1: Programs which can immediately provide information for the monitoring reports to be prepared for the first evaluation;

Group 2: Programs that, with identified capacity enhancement, can provide information coverage in areas that would otherwise be inadequately represented in the first monitoring evaluation reports;

Group 3: Programs which may be enhanced with capacity-building for future evaluation;

Group 4: Programs for which more information would be needed before categorization.

This grouping facilitates arrangements to use already existing available data as well as assistance for capacity building where needed. Most African countries fall under Groups 2, 3, and 4.

The following factors serve as guiding principles in the GMP design and reporting process:

- a) Only the substances contained in Annexes A, B and C of the Convention are considered for the moment;
- b) It is essential to ensure inclusiveness and transparency in all aspects of the GMP design and reporting process;
- c) Issues of compliance and proposition for additional POPs to the annexes of the Convention are not the focus of the GMP;
- d) Hot spots are not priority sources;
- e) Specific issues of scientific understanding.

2. DESCRIPTION OF THE AFRICA REGION

2.1 OVERVIEW OF GENERAL AND SOCIO-ECONOMIC FEATURES

Africa (Figure 2.1) is one of the largest continents in the world. The total area of the continent of Africa including the Indian Ocean and Atlantic Ocean Island States is 40, 065,721 square miles, and the total population of this area is 797,696,000 people. Africa is divided into Northern Africa, Southern Africa, Eastern Africa, Western Africa, Central Africa and the Island States as shown in Annex B Figure B1 (UNEP, 2002b).

Agriculture forms the backbone of the continent with most rural Africans being agrarian. The continent is rich in mineral resources, ranging from gold, diamond, bauxite, silver, to fossil fuels and other precious metals. These mineral resources are unevenly distributed in the continent.

Five official AU languages are spoken in Africa namely, English, French, Arabic, Portuguese, Spanish. Kiswahili is expected to be soon added to this list. It should be noted however, that each African country is constituted of many ethnic groups or subgroups that speak languages other than the five official ones. The dominant conventional religions are Christianity and Islam, but traditional religions are still being adhered to in several communities.

In the new millennium, Africa is characterized by two interrelated features namely, rising poverty levels and deepening environmental degradation. Globally, it has the largest percentage of people living on less than \$1 per day, and two thirds of the 48 countries included in the list of least developed countries (LDCs) are in Africa. In this regard, all efforts are geared towards the achievement of food security and poverty reduction. It is, therefore, not surprising that within the context of environmental issues more emphasis is placed on desertification and climate change issues which are prone to lead to problems of diminishing food resources and the capacity to enhance food security. The overuse and misuse of chemicals, including POP pesticides, to control pests and booster agricultural productivity could also be attributable to this desire to enhance food security.

2.2. POLITICAL STRUCTURES

Independence and self rule was introduced in most African countries in the late 1950s, allowing Africa to start taking its destiny into its own hands. Soon after, the process of uniting Africa started and one of these processes led to the birth of the Organization of African Unity (OAU) in 1963. The objective of establishing the OAU was to achieve greater unity and solidarity and to promote political and socio economic development in Africa.

Following the dissolution of the OAU in July 2002, the African Union (AU) was established the same year to capture the Organization's goal of establishing a common economic market and political union across the continent, thereby ensuring Africa's ability to play a more meaningful role in the global economy. The AU is a Pan-African body responsible for spearheading Africa's rapid integration and sustainable development by promoting unity, cohesion, peace and cooperation within African states as well as developing new partnerships worldwide. The AU has a mandate to promote regional cooperation on environmental management and conservation. Regional groupings, particularly economic communities such as the South African Development Cooperation (SADC), the Economic Community of Central African States (ECCAS), the Economic Community of West African States (ECOWAS), Common Market

for Eastern and Southern Africa (COMESA), East African Community (EAC), Community of Sahel-Saharan States (CEN-SAD) and the Union du Maghreb Arabe (UMA) now form part of the AU.

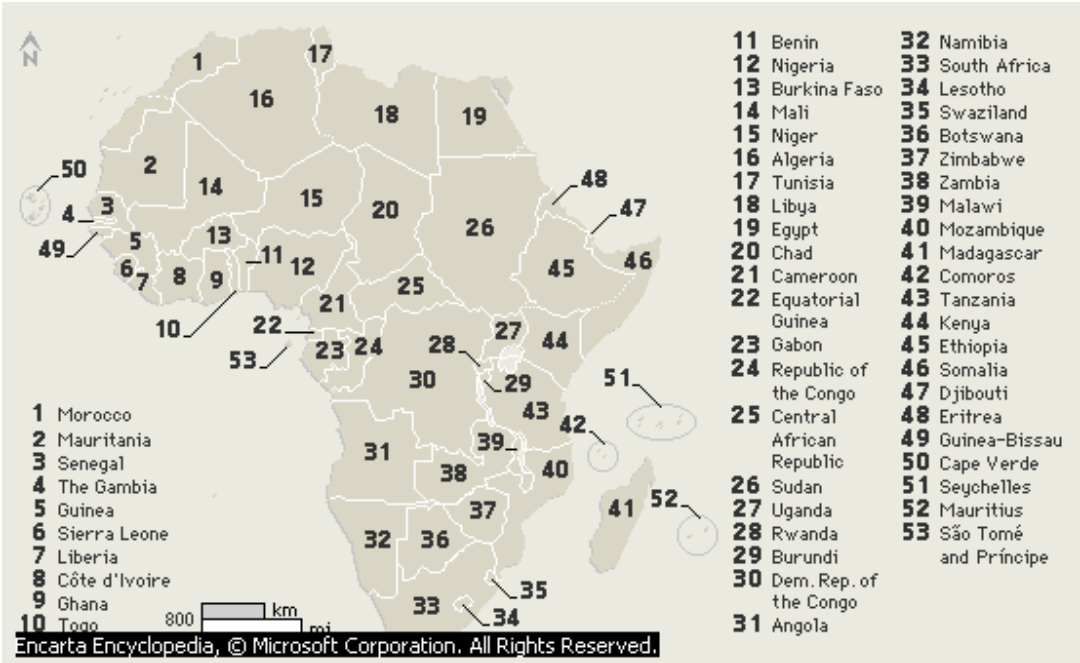


Figure 2. 1: A map of Africa showing the different countries

2.3. CLIMATIC AND GEOGRAPHICAL CHARACTERISTICS

2.3.1. Climatic characteristics

Climate variability is a normal part of Africa’s climate (Annex B Figure B 2). Periods of drought and flood, warmth and cold have occurred interchangeably in the past (Ropelewski and Halpert, 1987; Ogallo,1988; Nicholson and Kim, 1997; Tyson et al., 2002). Most countries in Africa are already vulnerable to extreme climate events such as tropical cyclones, droughts and floods. Daily variability in climate over Africa occurs through diurnal effects such as land-sea breezes, local topographic and coastal effects on airflow into lower latitudes (Tyson and Preston-Whyte, 2001). Sea surface temperatures (SSTs) in Atlantic and Indian Oceans are the primary influence of African inter-annual rainfall fluctuations and are linked to the El Niño-Southern Oscillation (ENSO) phase shifts (Rocha and Simmonds, 1997; Nicholson and Selato, 2000; Reasons et al., 2000). There exist association between the wet (dry) conditions on the African continent and cold (warm) sea surface temperature conditions in the Atlantic and Indian Oceans (Nicholson and Kim, 1997; Reason et al., 2000). At irregular intervals the North Atlantic Oscillation (NOA) and ENSO events have major impacts on inter-annual climate fluctuations on the continent (Tyson, 1986; Ward, 1998; Reason et al., 2000).

The intertropical convergence zone (ITCZ) or monsoon trough dominates Africa’s climate (Lewis and Berry, 1988; Waliser and Gautier, 1993). This ITCZ shifts over the land from one hemisphere to another in sympathy with the shift in areas of maximum solar heating. Significant latitudinal differences in climate exist across the continent in response to differences in land sea distribution, topography and geographical

location in relation to subsidence associated with the subtropical high pressure cells. Rainfall across the continent varies from about 1,500 mm yr⁻¹ in the equatorial regions to <50 mm yr⁻¹ over Northern Africa (Sahara desert region) and to <300 mm yr⁻¹ in Southern Africa. In Southern Africa, there is also an east-west gradient with rainfall varying from about 900 mm yr⁻¹ to <50 yr⁻¹ in the western regions (Kalahari Desert region).

Easterly and westerly wave disturbances form a major component of the continent's climate system. About 10% of the wave disturbances later intensify into tropical storms or cyclones (Tyson and Preston-Whyte, 2001). The tropical cyclone formation follows preferred zones in the Atlantic and Indian Oceans during summer. Pre-requisites for tropical cyclone formation include: warm sea surface (26-28°C to a depth of about 60 m), low-level convergence to maintain sensible and latent heat supply and upper level divergence to maintain ascent (Mason, 1995). Major moisture sources for rainfall over the continent are the gulf of Guinea and Congo basin, and the Atlantic and Indian oceans (Rocha and Simmonds, 1997).

Onset of summer monsoon in west Africa is linked to an abrupt latitudinal shift of the ITCZ from a quasi-stationary location of 5°N in May-June to another quasi-stationary location at 10°N in July-August. The mean date of summer monsoon onset is 24 June with a standard deviation of 8 days. The pre-onset stage is characterised by the arrival in the Sudano-Sahelian zone of intertropical front (ITF), a confluence line between moist southwesterly monsoon winds and dry northeasterly – the Harmattan – at 15°N (Taljaard, 1986; Shinoda and Kawamura, 1994).

2.3.2. *Vegetation characteristics*

The principal controls on the distribution of vegetation in Africa are total annual rainfall and the timing, duration and intensity of the dry seasons (Street-Perrott & Perrott, 1993). It has been noted that, according to the partly floristic and partly physiognomic vegetation classification of White (1983), the vegetation of Africa bears a close relationship to the large-scale climate of the continent (Street-Perrott & Perrott, 1993).

The sub-tropical and temperate seasonal climates are characterized by vegetation that is fire prone, comprising unique fire-dependent ecosystems that have evolved with fire as integral to biodiversity persistence and ecosystem functions. Fire is also widely used by people to manage such systems for human benefits, especially for improving grazing potential. In most of these ecosystems grazing by livestock is itself an important influence on vegetation structure and may limit fuel accumulation, leading to the potential for quite rapid human-induced changes in fire regime, and resulting switches in vegetation structure such as bush encroachment. The impact of disturbances by fire is therefore a key component of consideration in monitoring the emissions of un-intentional POPs on the continent.

2.3.3. *Geographical characteristics*

The following is an overview of some of the most prominent features in Africa: The longest river in Africa is the Nile with a length of 6,695 km and a large catchment or basin area of 3,720,000 sq km covering Egypt, Sudan, Uganda, Tanzania, DRC Congo, Burundi, Rwanda, Kenya, Eritria and Ethiopia. The largest lake is Lake Victoria, which is about 69,000 sq km and 1,130 meters above sea level, bordered by Uganda, Kenya and Tanzania. The highest mountain is the Kilimanjaro in north eastern Tanzania with a height of 5,895 meters high while the largest desert in Africa, the Sahara, is more than 3.5 million square miles and covers part of northern and western Africa.

Because of heavy rains and large water bodies, POPs on land and water environments may be carried away in run-offs. Low lying countries and cities will easily receive these run-offs. Some cities for example in

Western Africa are flat and low-lying (below sea level) while others in Eastern Africa lie 4,500 m above sea level.

2.3.4. Biodiversity Characteristics

Sub-Sahara Africa (SSA) is home to a significant portion of global biodiversity, both faunal and floristic. Africa as a whole contains about one-fifth of all known species of plants, mammals and birds, and about one-sixth of the amphibians and reptiles. Such riches in biodiversity is perhaps not surprising given that SSA covers a remarkable climatic and topographic range, from equatorial rainforest through to temperate regions of Southern Africa, with limited representation of alpine climates at mountain tops, and with rainfall seasonality ranging from all-season, summer-season and winter-season, incorporating some of the driest regions of the world in form of the Namib Desert.

The region contains four biodiversity hotspots that together host 3.5% of the world's endemic plant species and 1.8% of endemic vertebrate species in areas that are reduced from their original extent by between 73.2% and 93.3% (Myers et al., 2001), statistics that indicate a potentially high level of threat to Africa's endemic biodiversity. There appears to be an increasing exposure of natural ecosystems to human impacts in SSA, despite the generally low population densities outside of the major urban centres.

African biodiversity is, as in other parts of the world, positively correlated with human population densities (Balmford et al., 2001), with significant implications for human impacts on species persistence into the future. Human pressures on biodiversity is increasing strongly in many parts of the sub-continent, with direct use through, for example, bush meat harvesting threatening to extirpate many species of a variety of types (Bowen-Jones and Pendry, 1999; Thibault and Blaney, 2003). Development and timber harvesting are threats in some areas, and land conversion to agriculture is transforming landscape, causing spatial fragmentation of ecosystems in many areas (Laurence, 1999; Kemper, Cowling and Richardson, 1999; Mentens and Lambin, 2000; Zhang, Justice and Desanker, 2002). The problem of alien invasive species is also increasingly seen as a threat to biodiversity on the continent (Morrison et al., 2004; Le Maitre, Richardson and Chapman, 2004).

Despite the varied threats, many sub-Saharan ecosystems retain substantial proportions of the biodiversity that occurred prior to the expansion of human and during the late Pleistocene. The region has retained almost a full suite of its mega-herbivores and large carnivores, in sharp contrast to all other continents of the world, although they have suffered significant reduction in areas over which they potentially range in the wild. The Congo Basin has retained a substantial proportion of its primary tropical forest and thus represents a globally important carbon store, and much of the tropical and sub-tropical savannah and woodland ecosystems are relatively intact. In South Africa, Scholes and Biggs (2005) found that biodiversity can be classified as more than 80% intact, according to an index which assesses the persistence of species richness across all land-use types.

The uniqueness of the African continent, in terms of geographical location, climate variability and diverse socio-economic activities, is significant in determining the environmental fate of PTS (and POPs). These conditions can influence the behaviour of POPs, for example, air monitoring data in Zimbabwe and Malawi showed that hot temperatures volatilise sprayed DDT into pockets of hot air and could drift down stream. DDT can condense on the ground when the temperatures are low. The distillation and condensation of PTS on top of cold mountains, like the Kilimanjaro, could also take place, although no data from Africa exists to confirm this. In addition, studies on the assessment of PTS also indicate that DDT and PCBs are the most encountered POPs in fish and marine environment since 1970s. The same studies also indicate widespread PTS contamination of foodstuffs of both plant and animal origin, including fish and fish products, breast milk and dairy products. Fish constitutes the major source of animal protein for coastal,

lacustrine and riparian populations of some African countries, and is thus an indirect source of exposure to POPs for these populations. POPs also occur in sediments of the major lakes such as Lake Victoria, and need to be addressed (UNEP, 2002a).

2. 4. AGRICULTURAL AND INDUSTRIAL ACTIVITIES

Agriculture is the biggest contributor to national GDPs of most African countries. However, over the past decades, industrialization is gaining ground in several countries. An overview of agricultural and industrial activities in Africa region is given below:

2.4.1 Agriculture:

Most of the African countries' economies are based on agriculture, which contributes largely to the GDP and to the countries' exports. Several seasonal crops as well as cash crops are grown. Agricultural sector employs a large percentage of the population in the region.

The agriculture is sometimes plagued by periodic drought, and more persistently by land degradation caused by inappropriate agricultural practices and overgrazing, deforestation, population pressure, undeveloped water resources, and poor transport infrastructure. However, irrigation as well as other methods such as agricultural diversification strategies are being increasingly used to boost agricultural productivity.

The maritime fisheries sector as well as livestock production also occupy prominent places in the national economy of some African countries. Horticulture has expanded rapidly in the last two decades to become one of the largest contributors to GDP. As a result, fruit and vegetable conservation and transformation form an important part of the agro-food industry.

In response to the need to boost agricultural productivity and to attain food sufficiency, there is a tendency towards the use of chemicals such as fertilizers, veterinary chemicals, and plant protection substances. Pesticides constitute one of the major sources of PTS and POPs in sub-Saharan Africa. Pesticides are generally imported and not produced. However, pesticide formulation plants exist in many countries of the region. Sub-Saharan Africa imports less than 5% in terms of value of the total pesticides import of the world. The most widely used PTS pesticides including organochlorines are DDT, Endosulfan, Chlordane, Lindane (HCH), Heptachlor, Toxaphene, HCB and Aldrin (UNEP, 2002a).

In general, the following are the key features regarding agricultural sector in the region:

- a) Agriculture contributes 20-40% to GDPs of most countries in Africa
- b) Agriculture contributes to food security and is the main source of foreign exchange earnings in most African countries
- c) Fisheries occupies an important place in agriculture in most countries
- d) Industry contributes 4-32% to the GDP in most countries
- e) Main constraints include-inappropriate agricultural practices, lack of modern technology and techniques, disastrous climatic conditions, lack of awareness on the use of harmful products, lack of adequate laws and monitoring schemes on chemicals used in agriculture and industry.

2.4.2 Industry:

The industrial sector, despite its small contribution to GDP, supplies important consumer goods both to the domestic and international markets. The main manufacturing products are textiles, foodstuffs, beverages, leather and non-metallic products. The industrial sector is progressively gaining ground in many African countries. It now represents 4% to 32% of national GDPs in most African countries. Having been dominated by food industries for a long time, the industrial sector has rapidly diversified due to the rise of certain strategic chemical sectors such as petroleum, pesticide and pharmaceuticals, among others. Other sectors that contribute significantly to the GDP are the services sector and tourism (which includes the hotel industry). Mining is also an important activity in some countries.

To meet its developmental needs, Africa imports increasing amounts of various types of chemicals for industrial, domestic and agricultural purposes, and even for cosmetics, food, plastics, laboratory, petroleum, and a host of other uses. On the other hand, some countries have successfully diversified their economic activities by carving out special niches in textiles, financial services, information & communication technologies.

2.5. ENVIRONMENTAL HEALTH SCENARIO LINKS TO POPs

The region of Africa offers significant potential for human, social and economic development. However, it is facing enormous challenges such as rapid population growth, rising levels of poverty, diseases, and inappropriate development practices which are also the main factors that affect the regional state of the environment. Exacerbated by rapid population growth, poverty remains the primary cause of most of sub-Saharan Africa's environmental health problems. Half of Africa's population has no access to health services and two thirds lack safe drinking water.

With regard to diseases, in many sub-Saharan African countries, malaria remains a national health priority and a big concern to the Governments. A review conducted in The Gambia reported that 40% of all deaths in children between the ages of 1-4 years are due to malaria, a figure higher than the continental average of 10-30%. This trend seems to persist to date in many African countries. One of the greatest challenges facing malaria control worldwide is the spread and intensification of parasite resistance to antimalarial drugs. The limited number of such drugs has led to increasing difficulties in the development of antimalarial drug policies and adequate disease management. The Roll-back Malaria Programs championed and implemented by several African Governments has still not registered significant impacts.

The use of DDT in agriculture has been banned in almost all countries, and some countries have extended this ban to public health applications. However, in some countries, DDT is still used for indoor residual spraying to control malaria vector. The use of DDT was addressed at the 1995 meeting of the WHO Study Group on Vector Control for Malaria and Other Mosquito-Borne Diseases. The Study Group stated that DDT may be used for vector control, provided that it is only used for indoor spraying, it is effective, the WHO product specifications are met, and the necessary safety precautions are applied for its use and disposal. Under the POPs Convention, several countries are considering or have decided to phase out DDT use in their public health services over periods of between 3 and 8 years.

Considering the fact that DDT might play a role in combating malaria in future, particularly in the poorest endemic countries, it was suggested that restrictions on DDT for public health use be accompanied by

technical and financial mechanisms to ensure that effective malaria control is maintained through vector control methods that depend less on pesticides generally, and on DDT in particular.

Due to lack of knowledge on environmentally sustainable alternatives and proper quality control of agricultural products, African farmers have greatly increased their use of chemical based insecticides, herbicides, and fungicides. Persistent Organic Pollutants are still being used or stocked in make shift stores where the dangers and risks due to exposure are enormous. The stock is sometimes comprised of packages of substandard, deteriorated pesticides including POPs, as shown in the picture below. At least 20,000 tons of obsolete pesticides and tens of thousands of tons of contaminated soils have accumulated in most African countries over long periods (FAO, 1998). More recent FAO estimates are that there might be more than 40 000 tons, perhaps even much more, of these chemicals stocked or discarded over many parts of Africa (UNEP, 2002a). These pesticides pose a serious threat to the health of both rural and urban populations and contribute to land and water degradation. The main causes of accumulation of obsolete pesticides in Africa are:

1. Pesticides for locust and malaria control
2. prolonged storage of products under non optimal storage conditions;
3. unnecessary donations, particularly under the KR2 scheme;
4. banned, unlabelled or illegally imported products.



Plate 2.1: Stock of hazardous chemicals in an African country (Source: NIP Project Implementation Report-The Gambia-16/1/2003).

Many cases of acute pesticide poisoning, including those with only minor effects, occur annually in Africa, making them a major public health problem. The source of poisoning can stem from inappropriate storage and disposal facilities. Chemicals such as fertilizers and persistent organic pollutants previously widely used in agriculture and for disease vector control, continue to contaminate water bodies. POPs are also used in industry or are generated as by-products in industrial processes.

The major industrial PTS (including POPs) chemicals of concern in the region are adjudged to be the following: PCBs (mainly from electricity generating industry), HCB (also a PTS pesticide), pentachlorophenol (PCP) and phthalates (UNEP, 2002a). Since the early 1930s PCBs have been widely used as dielectric fluids in electrical transformers and capacitors. The minor applications of PCBs in equipment have been as heat transfer fluids and hydraulic fluids in industry, and as cooling fluids in

switches, voltage regulators and motors. Open applications of PCBs have been as plasticizer in paint, plastics and sealants and in carbonless copy paper.

PCBs themselves or PCB contaminated equipment stored as waste and/or more commonly PCB containing equipment still in service exist in many countries. They may be found in closed electrical systems, in partially closed applications or as heat transfer and hydraulic fluids, vacuum pumps, switches, etc. Draining of old transformers containing mineral oil and PCB-contaminated mineral oil, as well as their inconsiderate disposal can lead to leakage and contamination of the soil (Plate 2.2). Therefore, suitable storage facilities that comply with the obligations of the safe storage management plan of the Basel and Stockholm Conventions are in place. In some African countries, metal scrap from transformers have been known to be transformed into cooking pots by local smiths, such pots are used domestically, and mainly by women.

Plate 2.2 below is an example of an abandoned leaking transformer.



Plate 2.2: Leaking electrical transformer in an abandoned area in an African country (Source: GTZ PCB Project, The Gambia 1/6/2000)

Contamination of the environment can also occur through industrial processes (e.g. polychlorinated biphenyls (PCBs) and heavy metals), agriculture (pesticides), or accidental industrial by-products (e.g. polychlorinated dibenzo-p-dioxins and furans-PCDD/Fs). Mining can also have a variety of detrimental environmental effects, including contamination of groundwater with heavy metals, and silting and sedimentation of riparian ecosystems. Medical waste incineration, lack of shredder plants, burning of scraps, steel fabrication with welders having limited protective gears and domestic waste burning all contribute to dioxin and furan contamination.

A large amount of accidental and deliberate combustion is taking place, including the burning of rubber tyres as well as the stripping insulation of copper wires and cables. Waste combustion could potentially be the largest source of dioxins and furans in Africa. Moreover, burning of sugar cane fields, a common practice in sugar producing countries, could also contribute to the formation of dioxins. A daily TEQ production of around 60g (21360 g TEQ/year) for dioxins and furans for Sub Saharan Africa has been estimated based only on uncontrolled domestic waste combustion (UNEP Chemicals, 2002). This would

equate to 0.0003 g TEQ/year per capita, but does not include industrial or any other anthropogenic or natural sources as these were not taken into consideration in the assessment (UNEP Chemicals, 2002).

Uncontrolled and widespread combustions of materials (Plate 2.3) at household levels, and in industrial processes present a serious threat to human health due to release of POPs and particularly dioxins and furans.



Plate 2.3: Open Burning of Waste at the Dandora Dumpsite (Source: Kenya NIP, 2007)

The long term inappropriate use of POPs in agriculture and vector control, as well as in industries, and exposure from uncontrolled burning, may result in the presence of these toxic chemicals in human blood and breast milk.

The trend of concentration observed in Sub-Sahara Africa for PTS is DDT > PCBs > toxaphene. The report indicated that humans were less directly exposed than animals and vegetation to PTS during the period 1970 - 2002. However the main risk remains the food-web contamination. The occurrence of relatively high levels of DDT, PCBs and dioxins/furans in adipose tissues and blood of occupationally exposed persons is of immense concern. Equally disturbing is the high levels of HCB, Lindane and endosulfan in human breast milk in the region, in view of WHO's vigorous campaign that mothers breast milk is best for children. It has been established by studies in South Africa that Organochlorine Pesticides (OCPs) can be transferred to infants *via* breast milk (UNEP Chemicals, 2002).

It is to be noted that apart from POP pollution, Africa has to reckon with other major health issues; water in some parts of Africa is undrinkable due to contamination by bacteria, untreated or poorly treated sewage, heavy metals and silt from soil erosion, fertilizers and pesticides, mining tailings and industrial waste. The following can be given as a summary of the scenario in the region:

- a. Most African countries neither manufacture nor export chemicals but are importers;

- b. Food security being a priority, the potentials to use more pesticides is high;
- c. Malaria is still a leading killer disease, and the urge to use an effective insecticide such as DDT is high;
- d. Stocks of obsolete pesticides are still present in some African countries;
- e. POP contamination in environmental media is present but not inventorised;
- f. Both Agriculture and Industry can be responsible for hazardous chemicals pollution;
- g. Principal sources of PCBs in Africa are transformers and capacitors;
- h. Apart from pesticide poisoning, other hazardous chemicals including POP contamination in humans is not documented or reported;
- i. Some African countries still do not have in place monitoring schemes or even action plans on hazardous chemicals;
- j. Some African countries have still not developed or submitted their National Implementation Plans on POPs or even ratified the Stockholm Convention;
- k. Regulatory actions on hazardous chemicals are not undertaken by some countries;
- l. The WHO, RECETOX and other international Programs on the monitoring of POPs in breast milk and environmental media presently do not cover all African countries.

The names of countries that have signed and ratified the Stockholm Convention as well as those that have transmitted their NIPs can be found in Table A1, in Annex A.

In response to the need to address the above problems, African countries have taken individual and collective control measures and steps to halt the negative impact of toxic chemicals. These measures include:

- a. Programs in place to dispose of obsolete stocks of pesticides and clean up of contaminated sites;
- b. Development of action plans, monitoring schemes and programs on hazardous chemicals;
- c. Most countries have developed National Profiles to assess their countries' capacities for chemicals management;
- d. Some countries had or have on-going programs on Inventory of POPs and other hazardous chemicals;
- e. Some countries have established databases or registries on chemical imports, exports, use, incidents etc;
- f. Regulatory actions are being taken by many countries on hazardous chemicals including POPs, particularly through the Rotterdam Convention requirements;
- g. Most countries have banned DDT in agriculture but some allow its use in vector control, especially in malaria cases;
- h. Pesticide Formulation Laboratories have been established by several African countries;
- i. Most African countries are signatories to chemical conventions; Bamako/Basel, Rotterdam, Stockholm, Vienna/Montreal, Kyoto Protocol;
- j. Most African countries participate in regional and international programs on chemicals regulation; IFCS, SAICM, GHS, Risk Management of UNITAR; ASP, CILSS Common Regulations on Pesticide and other similar ones in other RECs;
- k. Most African countries have developed or are in the process of developing their NIPs on POPs;
- l. WHO Monitoring Program on POP in breast milk and human tissues, the RECETOX programs on POPs in environmental media, GAPS, UNEP/DGEF Capacity building Programs, are on-going.

Given that human and environmental health in Africa is strongly is strongly linked to socio-economic factors such population growth, economic growth and poverty, the proposed measures must be implemented in the framework of sustainable development.

Thus, in order to ensure the success of the proposed measures, the following issues must be taken into consideration: lack of awareness, need for capacity building, need for technology transfer, need for stricter control of porous borders, need for domestication of Conventions, lack of availability and access to data, weak infrastructure such as limited analytical capacity of laboratories to measure POPs levels in human tissue and environmental media, and lack of environmentally friendly alternatives to some POPs such as DDT.

3. ORGANIZATIONAL ARRANGEMENT AT REGIONAL LEVEL

Based on issues raised in chapter 2, it is deduced that the regional approach to the management of hazardous chemicals as an environmental issue is holistic, i.e. it is not isolated from other environmental and health problems. The GMP exercise is not only an environmental but a health issue and touches on the sustainable development aspects of the continent. This chapter describes the strategy and organisational arrangements put in place by the Regional Organization Group (ROG) members in order to implement the activities of the Global Monitoring Plan in the Africa region.

The region was divided into six zones or sub-regions (see Table 3.1 below). Each sub-region was under the coordination of an ROG member.

Table 3.1: Countries grouping and coordinating ROG members

Rep. of Congo	Ethiopia	Kenya	Mali	Morocco	Tanzania
Cameroon	Egypt	Burundi	Niger	Algeria	Zambia
Democratic	Sudan	Uganda	Chad	Libyan Arab	Zimbabwe
Republic of	Djibouti	Mauritius	Senegal	Jamahiriya	Mozambique
Congo	Somalia	Madagascar	Guinea	Tunisia	Namibia
Central	Ethiopia	Rwanda	Guinea-Bissau	Morocco	Botswana
African		Seychelles	The Gambia	Mauritania	Swaziland
Republic		Eritrea	Cape Verde		South Africa
Gabon		Kenya	Sierra Leone		Lesotho
Angola			Liberia		Malawi
Sao Tome and			Côte d'Ivoire		Comoros
Principe			Burkina Faso		Tanzania
Equatorial			Ghana		
Guinea			Benin		
Republic of			Nigeria		
Congo			Togo		
			Mali		
Coordinating ROG members (Country of origin)					
Mr. Mr. Jean de Dieu Nzila (Rep. of Congo)	Mr. Mohammed Ali (Ethiopia)	Mr. Vincent Odongo Madadi (Kenya)	Ms. Halimatou Kone Traore (Mali)	Mr. Najib Belmikki (Morocco)	Mr. Enoch Masanja (Tanzania)

3.1. COORDINATING ARRANGEMENTS ROG AND RCG ACTIVITIES

The main objectives of the Regional Organisation Groups (ROGs) as stated in the introduction were to define and implement regional strategies for information gathering including capacity building and to prepare monitoring reports for the first Effective Evaluation.

Each ROG member was tasked with receiving data from respective countries, under his/her coordination, which would go towards the preparation of the regional monitoring report. Readily available data could be obtained from international and national programmes and on-going activities. Where primary data was not available, summarized data from programs fulfilling the criteria set out in the GMP guidance document was considered. The Stockholm Convention Focal Points were also involved in the process of data provision from their Parties.

During the regional inception workshop held in October 2007, in Nairobi, Kenya, the regional organization group members agreed that each (ROG) member coordinates one sub-region. They selected three members (the ROG members from Kenya, Mali and Morocco) who would represent the region on the Global Coordinating Group Committee, and the ROG Coordinator (the ROG member from Kenya) for the African Region.

In addition to the above tasks, the ROGs members convened, conducted and participated in GMP related meetings, hired consultants, reviewed and approved work of drafting consultants. They were also responsible for submission of the final regional report to the Stockholm Convention Secretariat.

Meetings of ROG members

a) Inception workshop

Regional Organization Group inception workshop for the African region took place from 29-31 October 2007, at UNEP Headquarters in Nairobi, Kenya. The workshop was hosted by the UNEP Regional Office for Africa. The aim of the workshop was to present and discuss the main elements of the regional monitoring plan and to obtain commitments for their implementation. The main objectives were:

- 1) To establish a strategy, work plan and timetable for the regional organization group;
- 2) To agree on arrangements to receive readily available data;
- 3) To establish strategic partnerships to produce supplementary data and to provide enabling capacity strengthening;
- 4) To identify necessary enabling capacity-strengthening to Group 2 Programs;
- 5) To establish arrangements for regional cooperation;
- 6) To establish arrangements to draft the regional monitoring report.

The presentations made at the meeting revealed that countries in the region were at different stages of development of their National Implementation Plans on Persistent Organic Pollutants, which might influence their preparedness to participate in the global monitoring plan. Participants were also informed that some data human contamination was available, but could possibly be skewed to highly exposed populations. In general population data taken for reference purposes could serve as background data for human samples. It was also highlighted that interpretation of monitoring data from different sources and generated for different purposes in the regions must be done with caution, since under GMP, consideration is for background data. It was revealed that monitoring data on dioxins was almost non-existent, particularly due to lack of laboratory infrastructure and the high cost of analysis.

b) Follow-up workshop

A second workshop (following on the Nairobi Meeting) was held in Lome, Togo from the 25th to the 27th February 2008, to facilitate the implementation of GMP activities in the francophone African countries. The workshop was facilitated by the Stockholm Convention Secretariat, and hosted by the Ministry of Environment of the republic of Togo.

c) Regional Drafting workshop

A regional drafting workshop was held from 14th -16th July 2008, in Nairobi, Kenya. The aim of the meeting was to review progress in the drafting of the regional report and to gain the approval of other regional members on the content of the final report. The meeting was hosted by the University of Nairobi.

d) Other Meetings

A Drafting workshop took place in Geneva, Switzerland from the 19th to the 23rd May 2008 under the auspices of UNEP Chemicals. The purpose of the workshop was to assist and guide ROGs in the drafting of the regional reports on the GMP monitoring. The workshop also offered an opportunity for ROGs to raise specific concerns and issues regarding the reports and to receive appropriate guidance.

e) E-Forums

Apart from these meetings and workshop, ROGs participated in several e-forums organised by CIEN to obtain additional information on the GMP and related issues. An African ROG/ESTIS platform was also created to encourage communication between ROG and other stakeholders.

3.2. STRATEGY TO COLLECT INFORMATION

The ROG members developed a template for data collection and circulated it to all Parties. They were also tasked with identifying and reviewing appropriateness of data comparability before transmission to drafting team. The collected data is stored at ESTIS database at UNEP and could be accessed through: <http://www.ESTIS.net/sites/rog/>. The templates used for data collection are in Annex C Tables C1 and C2.

3.3. EXISTING CAPACITY TO ANALYSE POPs IN AFRICA

Although limited capacity exists in Africa, there is nonetheless an existing potential at national and regional levels that can be used as a basis for cooperation in the GMP project.

Overview of existing capacity at regional and national levels for GMP

The Tables 3.2 below summarises the existing national institutions with capacities or potential capacities to participate in the GMP. The information was gathered during the Regional organization group inception workshop held in October 2007, in Nairobi, Kenya. Additional information on research activities and POPs monitoring capacities is given in Annex C, Tables C3 and C4.

Table 3.2: National Capacity to analyse POPs in Africa.

Country	Institution	Capability
Kenya	Department of Chemistry, University of Nairobi	<ul style="list-style-type: none"> • Has been conducting research in POPs pesticides since 1978. • Currently monitoring POP pesticides and PCBs in Lake Victoria drainage basin and other parts of the country. Matrices: water, sediments, vegetation, fish, and soils • Also involved in monitoring POP pesticides and PCBs in Indian Ocean-WIO Lab Program, Matrices: sediments and bivalves. • Leading NRBP-water and sediments analysed for parameters including POP pesticides and PCBs) • Apply EU recommended SOP for PCBs and POP pesticides. • Participated in UNEP/GEF POPs project inter-laboratory calibration study, 2007 for PCBs and POP pesticides in sediment and biota. • Participated in IAEA inter-laboratory calibration study for POP pesticides for sediment and biota, 1999. • Data archiving: research theses and publications in international journals.
	University of Nairobi, Department of Public Health Pharmacology and Toxicology	<ul style="list-style-type: none"> • Human milk POPs research and monitoring conducted in 1986, 1992 and 2004. • Mainly POP pesticides and PCBs. Mainly research for award of degrees.
South Africa	North-West University South Africa	Persistent Organic Pollutants and Toxicants (POPT) Research Group: <ul style="list-style-type: none"> • Mainly academic research Programs • Matrices: Breast milk, bird eggs, soil, sediment. • Analytes: POP pesticides and PCBs • Published data on DDTs in breast milk are available for 2002
Sudan	University of Gezira	<ul style="list-style-type: none"> • Research on POPs pesticides started early 1970's. • Data on POP pesticides from research activities not monitoring Program. • Lack of facilities for PCBs, furans and dioxins.

Others national institutions identified include:

- a) National Institute for Sanitation Laboratory-Togo;
- b) Lab of the Togolese Agronomic research institute (EU and UNIDO support for accreditation);
- c) Cairo Central Centre (CCC) Egyptian Environmental Affairs Agency (EEAA);
- d) Central laboratory for residues of pesticides in food, Ministry of Agriculture, Egypt;
- e) CERES-Locustox laboratory in Dakar, Senegal;
- f) TPRI –Tanzania;
- g) CPE Chemistry Dar-Es Salaam Tanzania;
- h) Government Analytical Laboratory, Uganda;
- i) Faculty of Agriculture and Sciences, Sudan;
- j) National Chemical laboratory, Ministry of Health, Sudan;
- k) Mauritius Sugar Industry Research Institute (MSIRI);
- l) National Environmental Laboratory (NEL), Mauritius;
- m) The Water Research Institute of the Council for Scientific and Industrial Research (CSIR-WRI), Ghana;
- n) The Ghana Standards Board (GSB);
- o) The central Veterinary Laboratory: Environmental Toxicology Laboratory, Mali;
- p) University of Sierra Leone, Fourah Bay College.

Table 3.3: Regional Capacity:

ANCAP	<ul style="list-style-type: none"> • Is a regional network • Mainly for capacity building of scientists to conduct research in institutions of higher learning. • Analytes: pesticides including POPs pesticides and PCBs • Matrix: mainly water, sediments, fish and soil. • With capacity enhancement, member countries may contribute to POPs monitoring of GMP matrices
EADN,	<ul style="list-style-type: none"> • Planned project for ambient air sampling, does not plan to analyse POPs; • Matrix to be monitored-Air • Analytes: P, N, SO_x, NO_x • With capacity enhancement could help in POPs monitoring in air.
NEPAD	<ul style="list-style-type: none"> • Established for the socio-economic and environmental advancement of Africa. • Has elaborated 28 project proposals on issues related to environmentally sound management of pesticides and other toxic chemicals. • Some of the projects that have links to POPs and may facilitate the GMP Project include: <ul style="list-style-type: none"> ➤ Supporting the implementation of the Stockholm Convention through the NIP Project; ➤ Agrochemical pesticides and the African Stockpiles Projects; ➤ Preparation of national inventories of PCBs and PCB-containing equipment in SADC sub-region; ➤ Survey of chlorinated dioxins, dibenzofurans and PCBs in the major waters of South Africa; ➤ Monitoring of environmental contaminants in environmental samples and marketable products and monitoring of atmospheric environmental issues.

Others regional institutions/programmes include:

- a) Monetary Union of West Africa (UMEOA) including, 8 francophone member states, is supported financially by the EU and technically by UNIDO to promote Quality Management System in food commodities and cash crops;
- b) Passive air sampling capacity will be available in the framework of the IAA project, however POPs are not considered;
- c) SADC-passive sampling network, most SADC countries are involved, since 1999; possible partnership with RECETOX;
- d) NEPAD Action plan on Chemicals. The Regional Coordination Office for Africa could facilitate this information exchange.

3.4. PARTNERSHIPS AND AVAILABLE CAPACITY OF INTERNATIONAL PROGRAMS TO FILL DATA GAPS

Africa cooperated with various partners to implement the GMP activities, and to bridge the existing data gaps that are elaborated below.

3.4.1. Data gaps

- a. Lack of milk data in most of the sub-regions
- b. Lack of systematic monitoring of POPs in the core media (ambient air and human milk or blood)
- c. Unavailability of data on PCDD/PCDF and limited data on PCBs
- d. Limited human capacity to analyse POP pesticides and PCBs in soil, sediment, water, vegetation, milk and air.
- e. Limited operational laboratories with basic equipment for analysis of POP pesticides and PCBs.
- f. The need to establish Programs to produce additional data on the GMP matrices to fill the existing gaps.

3.4.2. Strategy to fill the gaps

The data gaps may be filled through:

- 1) National capacity enhancement;
- 2) Multi country projects:
- 3) Possible partnership arrangements:
 - Sub-regional partnership
 - Inter-regional partnership
- 4) International partnership
 - a) Proposal for a GEF supported project: GEF plans to undertake further training for laboratories to fully integrate them into inter-calibration studies, expand the spectrum of POPs analysed and expand the number of matrices analyzed.
 - b) Proposal for RECETOX Project: In support of capacity building, countries with capacity to analyze both OCPs and PCBs (including appropriate standards) immediately will receive an additional sampler for co-sampling for in-country analysis.
 - c) Czech Republic proposal: Possible further capacity strengthening in the form of Summer Schools for PhD students (based on bilateral agreements with the Czech Republic) on passive air sampling, site selection, sample treatment and analysis, intercalibration, data handling, data interpretation, QA/QC.
 - d) WHO Proposals: There are proposals to conduct WHO proficiency testing for national laboratories.

3.4.3. Existing and potential partners

The following are identified existing and potential institutions or organizations for partnership and collaboration to enhance regional capacities for the purpose of filling POPs data gaps:

1) Existing partners

The collaborating partners that are already working on the ground include:

- a) **UNEP Chemicals:** The Secretariat serves as a clearing-house mechanism for information on Persistent Organic Pollutants, including information provided by Parties, intergovernmental organizations and non-governmental organizations. ROGs are offered the opportunity to seek and receive information from UNEP Chemicals, as needed.
- b) **CIEN:** The CIEN of UNEP chemicals has a mission to facilitate information access and exchange between countries, regions and subregions. It provides a connection to major specialized websites, to UNEP and UNEP Chemicals, and to the MEAs Secretariats. It offers e learning opportunities, interactive training material, as well as responses to queries. It organizes e forums on issues related to the Stockholm Convention, the NIPs and related issues, thereby rendering awareness and educational services to interested partners. CIEN provides a useful platform to locate both technical and scientific information that is vital to GMP.
- c) **GEF :** Two medium size GEF projects were established in the region to support the Implementation of the Global Monitoring Plan on POPs. The West Africa project covered DR Congo, Ghana, Mali, Nigeria, Senegal and Togo, whereas the Eastern and Southern Africa Project included Egypt, Ethiopia, Kenya, Mauritius, Uganda and Zambia. The projects focus on Gap Analysis and development of detailed guidelines, protocols and manuals, training of participating national and regional laboratories and provision of technical, backstopping by well established international laboratories, as well as strengthening analytical performance in participating countries by provision of consumables and spare parts for sampling and analysis of POPs in key matrices. It has as objectives the assessment of Convention-driven country needs for laboratory analysis and conditions necessary to conduct them in a sustainable manner. In terms of piloting, GEF has activities in nine laboratories in seven countries from four UN regions, including Africa, with Kenya participating in the PCB/Organochlorine Pesticide (OCP) studies.
- d) **RECETOX :** Under RECETOX, a project on passive air sampling supported by the Secretariat of the Stockholm Conventions and co-financed by the Czech Republic was established. The project covered a six months long POPs Monitoring in fifteen countries in the region using passive air samplers. RECETOX offered to continue sampling and analysis for 2-3 years in countries willing to do parallel analysis and maintain air monitoring in the future. It also proposed fifteen sampling sites in partnership with Africa.
- e) **GAPS:** The Global Atmospheric Passive Sampling (GAPS) is a key program for producing comparable global-scale data for POPs and consists of more than 60 sites on seven continents. Its objectives are to i) demonstrate the feasibility of passive air samplers (PAS) for POPs; ii) determine spatial and temporal trends for POPs in air; and iii) contribute useful data for assessing regional and global long-range atmospheric transport of POPs. GAPS sampling stations in Africa were located in Ghana, South Africa, Malawi and Egypt.

- f) **WHO :** Under the WHO Program, breast milk samples were collected from the participating countries and sent to France for analysis. There have been four rounds of WHO milk surveys.

2) Potential Partners

The following were proposed as potential partnership opportunities that can be explored in the future for monitoring:

- Lab-network could be constituted in Francophone Africa supported by EU and UNIDO;
- Norwegian help to Kenya QA/QC and interlaboratory tests for the milk analysis;
- International Atomic Energy Agency: launching the project on passive air sampling in Ethiopia (samples to be analyzed in IAEA).

3.5. IDENTIFICATION OF CAPACITY STRENGTHENING NEEDS

Africa is faced with capacity strengthening needs which have to be overcome for the region to participate fully in the GMP Projects. The following were identified as the immediate needs during the inception workshop in Nairobi:

- a) Need for the acquisition of milk data
- b) To monitor systematically POPs in the core media (ambient air and human milk or blood)
- c) Need for sufficient data on PCDD/PCDF and PCBs
- d) Strengthening of human capacity to analyse POP pesticides and PCBs in soil, sediment, water, vegetation, milk and air is required.
- e) Need for operational laboratories with basic equipment for analysis of POP pesticides and PCBs.
- f) The need to establish Programs to produce additional data on the GMP matrices to fill the existing gaps.

3.6. ARRANGEMENT FOR DRAFTING OF REGIONAL REPORT

The African ROG members contracted the following consultants to draft the Regional POPs Monitoring report:

- 1) Ms. Fatoumata Jallow Ndoeye: a Consultant on Multilateral Environmental Agreements at the African Union in Addis Ababa, Ethiopia.
- 2) Dr. Komla Sanda: Professor of Chemistry at the University of Lomé, Togo.

The two consultants were tasked to compile all the available POPs data and the supplementary data generated from the Africa region, conduct necessary statistical analysis and present the report to the ROG in appropriate format recommended for the Global monitoring report (See TORs in Annex C Table C 5). The information on readily available data was transmitted electronically from the ROG to the consultants. The consultants were also allowed to conduct research to obtain additional appropriate information and to attend some ROG meetings.

4. METHODS FOR SAMPLING, ANALYSIS AND DATA HANDLING

To ensure its effective participation in the first effectiveness evaluation in 2009, the African region established a strategic partnership with RECETOX and GAPS on one hand, and WHO on the other, to help the region collect comparable POPs data for ambient air and human milk through their respective monitoring programs. This chapter summarizes the background information on these international programs along with their relevant technical procedures to sample media, to analyze POPs, to process and to handle data.

4.1 PROGRAMS/ACTIVITIES RELATED TO AIR MONITORING

Global Passive Sampling Programme (GAPs) and MONET Africa are the two programmes monitoring POPs in Ambient air in Africa. GAPs was launched in January 2005 in four countries (Egypt, Ghana, Malawi, and South Africa), with a total of five sites (Figure 4.1). MONET Africa was launched in January 2008, as a six month pilot project supported by the Stockholm Convention Secretariat and the Czech Republic, and covered 15 countries with a total of 26 sampling sites (Figure 4.4). Both programs use passive sampling, which is a well known cost-effective ambient air sampling technique.

4.1.1. Global Atmospheric Passive Sampling (GAPS) Network

4.1.1.1. Key message

The first year results (January–December 2005) from the Global Atmospheric Passive Sampling (GAPS) Network provide baselines of air concentrations for persistent organic pollutants (POPs) at four sampling sites in the Africa region (Figure 4.1). In many cases, these data represent the first measurements of POPs in this region and will be useful for assessing temporal and spatial trends and regional and global transport of POPs in air.

4.1.1.2. Background

The GAPS Network is a key program for producing comparable global-scale data for POPs. This program was initiated in December 2004 as a two-year pilot study before evolving into a network, and consists of more than 60 sites on seven continents. Its objectives are to i) demonstrate the feasibility of passive air samplers (PAS) for POPs; ii) determine spatial and temporal trends for POPs in air; and iii) contribute useful data for assessing regional and global long-range atmospheric transport of POPs. PAS are advantageous because of their low cost, simple construction and electricity-free operation. Deployment of PAS worldwide over several years will allow for temporal trends to be established and thus, the effectiveness of POPs control measures to be evaluated. The GAPS Network has been active at five sites in the Africa region since 2005 (Figure 4.1 and Table 4.1).

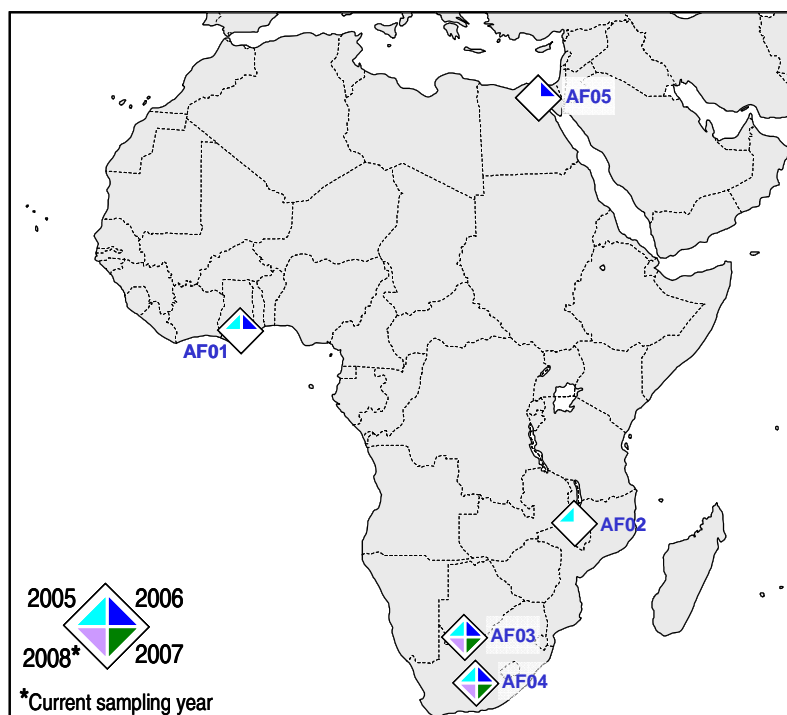


Figure 4.1: Sampling sites and sampling years in Africa

Table 4.1: Information on sampling locations in Africa

Site ID	Location	Country	Site Type ¹	Latitude	Longitude	Elevation (m) ²
AF01	Accra	Ghana	RU	8° 00' N	2° 00' W	NA
AF02	Lilongwe	Malawi	AG	14° 11' S	33° 47' E	1148
AF03	Kalahari	South Africa	BA	25° 52' S	22° 54' E	NA
AF04	De Aar	South Africa	BA	30° 40' S	24° 00' E	1287
AF05	Cairo	Egypt	RU	30° 08' 25.18" N	31° 37' 08.94" E	193

¹ m a.s.l. = Meter above sea level

² BA = background; RU = rural; AG = agricultural and UR = urban

4.1.1.3. Sampling

a) Types of PAS used:

Two types of PAS are used (Figure 4.2). The PUF-disk sampler (left) is deployed for three-month periods to capture seasonal differences and the XAD (right) sampler is exposed for a full year.

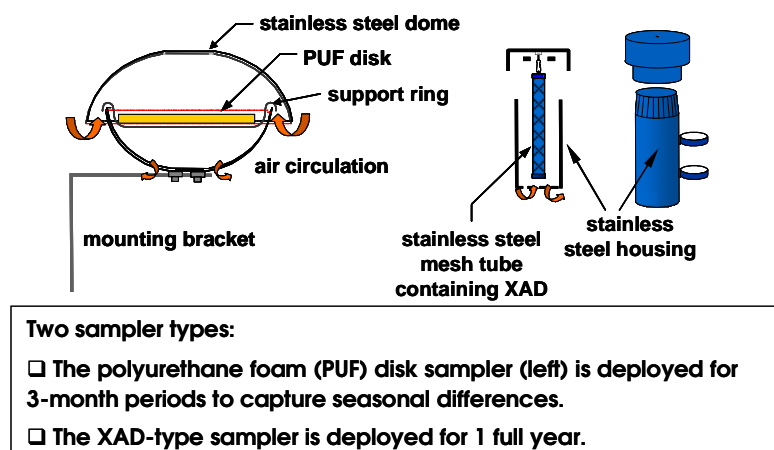


Figure 4.2. Schematic diagrams of passive air samplers

The PUF-disk sampler is described in Shoeib and Harner (2002) and Pozo et al. (2006) and the XAD sampler is described in Wania et al. (2003). Both types of PAS are installed outdoors far away from potential sources of contamination to the site (e.g., exhaust vents, electronics, sources of combustion or human activity). They are mounted approximately two meters above the ground in an open area with unobstructed airflow.

b) Sampling conditions

❖ PUF-disk PAS

PUF-disk PAS were deployed at four African sites in 2005. Table 4.2 shows the exposure times (days), average temperatures (°C) and effective sampling rates (m³/day) for each of the four sampling periods at each site. Generally, the PUF-disk sampling was as follows: January–March (Period 1); April–June (Period 2); July–September (Period 3); and October–December (Period 4).

❖ XAD-based PAS

XAD-based PAS were deployed at three African sites in 2005 and four sites in 2006. By sampling air for one year, XAD resin-based PAS provides annually averaged concentrations of organic pollutants. The sampling lengths and the sequestered amounts of selected OCPs in ng/PAS were assessed. Analyses were performed for the pesticides that are classified under the Stockholm Convention: CC, TC, TN, DDT, DDE, dieldrin, HEPT, and HEPX, and also for the pesticides that are not classified under Stockholm Convention, including α - and γ -HCH, Endo I and II, EndoSO₄, chlorothalonil (CT), dacthal (DT), and trifluralin (TF).

4.1.1.4. Sample analytical procedures

a) Procedure for PUF- Disk PAS

Details for the extraction and analysis of the PUF-disk samples and field blanks are given in Pozo et al. (2006). The following QA/QC procedures were employed for the PUF-disk sampler:

- a) Field blanks – A PUF disk field blank was collected once a year from each site to assess possible contamination caused by shipping, handling and storage.
- b) Method blanks – A solvent blank was extracted with every set of eight samples to assess possible contamination during laboratory analysis (i.e., from sample preparation to instrumental analysis). Also, during preparation of PUF disks for deployment, one sample from each batch was extracted and checked for purity.
- c) Instrument blanks – A solvent blank was analyzed with every set of twelve field samples to assess for any instrument contamination.
- d) Surrogate spikes – Prior to extraction, PUF-disk samples were spiked with a method recovery standard consisting of ^{13}C -PCB-105, d_6 - α -HCH, and d_8 - p, p' -DDT to confirm analytical integrity.
- e) Matrix spikes – Analytical (method) recoveries were determined by spiking clean PUF disks with known quantities of the target chemicals and treating them as samples to assess matrix effects on extraction efficiencies.
- f) Field co-located samples – Duplicate samples were collected at several sites in the GAPS Network to assess overall precision of both sampling and laboratory methods.

Mirex was added as an internal standard to correct for volume differences in sample extracts. All samples and field blanks were quantified for target compounds including organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs), and polybrominated diphenyl ethers (PBDEs). OCPs, PCBs, and PBDEs were analyzed on a Hewlett-Packard 6890 gas chromatograph-5973 mass spectrometer (GC-MS) using electron impact (EI) for PCBs and negative chemical ionization (NCI) for OCPs and PBDEs in the selected ion monitoring mode.

b) Procedure for XAD PAS

Cleaning of XAD-2 resin, and packing of XAD PAS samples were carried out as described by Wania et al. (2003). Cleaning, preparation and extraction of PAS were done in a clean lab. The XAD-2 resin was Soxhlet extracted with dichloromethane for 20 hours. Prior to extraction, the resin was spiked with standards consisting d_6 - α -HCH, $^{13}\text{C}_{10}$ -HEPX, $^{13}\text{C}_{10}$ -TN, $^{13}\text{C}_{12}$ -dieldrin, d_8 - p, p' -DDT and $^{13}\text{C}_{12}$ -PCB-32, $^{13}\text{C}_{12}$ -PCB-77, $^{13}\text{C}_{12}$ -PCB-118 and $^{13}\text{C}_{12}$ -PCB-126 to test for the loss of the compounds during the extraction and clean-up procedures. The extracts were volume reduced using a rotary evaporator and concentrated to around 1 ml using a gentle stream of nitrogen. The extracts from first year samples were cleaned using alumina columns, but not those from the second year. After reducing samples to 3 ml using a rotary evaporator, the extracts from second year samples were passed through sodium sulfate (baked at 450 °C overnight) columns to remove any water present in sample. The extracts from the first year air samples were cleaned on a column with 1 g of 6% deactivated alumina (baked at 450 °C overnight) and 0.5 cm of sodium sulfate. The samples were eluted with 20 ml of DCM: PE (5:95; v/v). The extracts were concentrated to 1 ml using a stream of nitrogen and then were solvent-exchanged to isooctane. The final volume of the extracts was 1 ml, and 100 ng of mirex was added to the sample as an internal standard for correcting volume differences in the sample.

The sample and blank (field and laboratory) extracts were analyzed for Stockholm Convention POPs as well as pesticides not classified under Stockholm Convention POPs using an Agilent 6890 gas chromatograph (GC) coupled to a 5973 mass selective detector (MSD) with a negative chemical ionization source for organochlorine pesticides (OCPs) in selected ion mode. The analyzed non-Stockholm Convention pesticides in air samples are: α -HCH, γ -HCH, α -endosulfan, β -endosulfan, endosulfan sulfate, dacthal, chlorothalonil, pendimethalin and trifluralin.

Quality assurance and control measures were used to monitor all analytical procedures. Field blanks were collected to determine the levels of contaminants introduced by handling, shipping and storage and one laboratory blank was analyzed for every set of sample extractions to determine the levels of contaminants introduced during extraction and clean-up. The laboratory blanks and field blanks were processed in the same way as the samples. Air samples were not spiked with surrogates for the pesticides that are not classified under the Stockholm Convention POPs, such as chlorothalonil, dacthal, metribuzin, pendimethalin, and trifluralin. To test for the loss of these compounds during the extraction and clean-up procedure, six samples of 20 g of XAD-2 were spiked with the pesticides, then extracted and cleaned in the same way as the samples.

4.1.1.5. Data comparability

All PUF-disk samples were prepared and analyzed in the same laboratory [Hazardous Air Pollutants (HAPs), Environment Canada in Toronto] to ensure that the data could be compared spatially and temporally. The HAPs laboratory participates in international intercalibration studies for POPs and performs well in these exercises.

4.1.1.6. Sample and data storage

Sample extracts were capped tightly in GC vials and stored in a freezer at a temperature of about -20°C. Air concentration results and relevant sample information (e.g. sample ID, site ID, location name, sample duration, meteorological conditions etc.) were recorded in Excel spreadsheets.

Table 4.2: Exposure times, average temperatures and effective sampling rates during deployment periods for PUF-disk sampling in 2005

Site ID 2005 ¹	Exposure Time (Days)	Average Temp (°C)	R ² (m ³ .day ⁻¹)
AF01	109	28	3.9
AF02	NA	NA	NA
AF03	95	25	5
AF04	89	22	6
AF05	NS	NS	NS
AF01	92	26	2.3
AF02	92	20	3.7
AF03	88	21	2.8
AF04	115	16	2.9
AF05	NS	NS	NS
AF01	92	25	2.7
AF02	NA	NA	NA
AF03	NA	NA	NA
AF04	109	14	5
AF05	NS	NS	NS

¹ Site ID: AF01 = Accra; AF02 = Lilongwe; AF03 = Kalahari; AF04 = De Aar; AF05 = Cairo

² R = effective sampling rate

* Mean sampling rate calculated based on 4 sampling periods.

NA = Sample not available

NS = No deployment in 2005

4.1.2. MONET-AFRICA-RECETOX Program

4.1.2.1. Key message

There is a general lack of information on the levels of persistent organic pollutants (POPs) in the African region like in many other parts of the world. Since the high volume air samplers are expensive devices requiring reliable power supply and trained operators are not widely available, the air monitoring of POPs has only been conducted at limited number of sites. As air pollution became an issue of great public health concern, and with new regulations introduced, a pressing need to obtain more POPs data in a cost-effective manner. Thus, the Global Monitoring Network was established to support the purpose of the Stockholm Convention, with the objective of establishing baseline trends at global background sites. Passive air samplers (PAS) offer a cheap and versatile alternative to the conventional high volume air sampling and they have been currently recommended as one of the methods suitable for the purpose of new long-term monitoring projects.

4.1.2.2. Background

MONET-Africa project was based on the Memorandum between UNEP (represented by the Secretariat of the Stockholm Convention) and Masaryk University, Brno, Czech Republic (represented by the Research Centre for Environmental Chemistry and Ecotoxicology RECETOX). This Memorandum was signed for the purpose of implementation of the Agreement between the Swedish Chemical Agency (KEMI) and the Secretariat of the Stockholm Convention on support of the global monitoring of POPs for evaluation of effectiveness of the Stockholm Convention. The project activities were further supported by: the Ministry of Education of the Czech Republic, Project MSM 0021622412, and the Ministry of Environment of the Czech Republic, Project SP/1b1/30/07.

A summary table of MONET Africa project organization and implementation plan is shown in Annex D, Table D 1. A list of the project participants from Africa and their contacts is also provided in Annex Table D 2.

Project goals and related activities:

- 1) Application of the polyurethane foam based passive air sampler (PAS) as a tool for determination of the effectiveness of measures of the international POPs conventions (POPs under the Stockholm Convention and POPs Protocol of CRLTAP). Establishment of the long-term monitoring of background sites as well as evaluation of an impact of the local primary point sources, secondary and diffusive sources, and a long-range transport is necessary. Design of the project is based on the experience from the pilot studies performed by RECETOX in the Czech Republic and Western Balkan since 2003 (Klanova et al., 2006; Klanova et al., 2007; Cupr et al., 2006).
- 2) Filling the information gap concerning POP levels in ambient air in the African continent where the regular monitoring programs are missing. Representative set of the sampling sites ranging from

industrial to background sites was selected in two countries (Mali and Kenya). In addition, one background site was also sampled in each of the other participating countries.

- 3) Evaluation of temporal and spatial trends in the POP concentrations in ambient air in the countries of the African continent. Variability of the POP levels between the sampling sites as well as the seasonal variability on each site were assessed.
- 4) Establishment of the long-term PAS monitoring program in this region. A monitoring network in the Czech Republic serves as a model for development of other networks. After completing both stages of the African screening study in August, 2008, the set of the sampling sites suitable for the long term monitoring will be selected and steps will be taken (in cooperation with the local institutions) towards the establishment of the regional monitoring program.
- 5) Transfer of know-how, dissemination of information about new techniques for sampling, chemical analysis, toxicological screening, and risk assessment. Educational and training activities, workshops and conferences initiated in the last five years under umbrella of the Research Centre for Environmental Chemistry and Ecotoxicology RECETOX, EU DG Research Centre of Excellence, will be promoted by Central and Eastern European POPs Centre to strengthen the scientific cooperation within and outside this region.
- 6) Presentation of activities of the Regional POPs Centre, National POPs Centre of the Czech Republic and Research Centre for Environmental Chemistry and Ecotoxicology RECETOX, Masaryk University, Brno, Czech Republic.

4.1.2.3. Sampling

Passive air sampling device consists of two stainless steel bowls attached to the common axes to form a protective chamber for the polyurethane foam filter. The filter is attached to the same rod and it is sheltered against the wet and dry atmospheric deposition, wind and UV light. Exposure times between four and twelve weeks enable determination of many compounds from the POP group. Average sampling rate was estimated to be 3.5 m³/day which roughly corresponds to 100 m³ of the air sampled during four weeks of deployment.

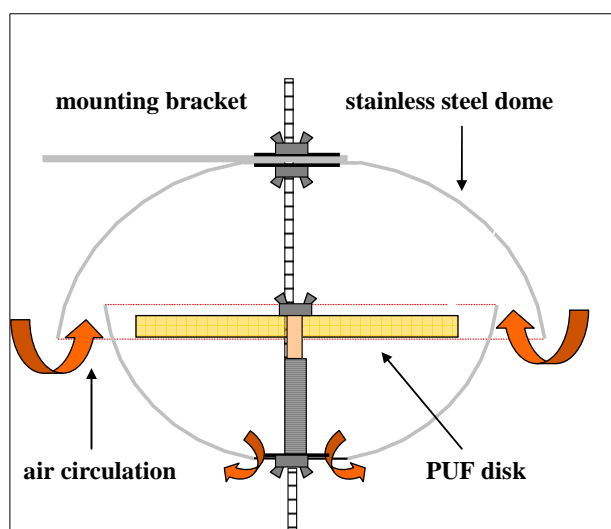


Figure 4.3: Schematic diagram of the passive air sampler

Previous RECETOX studies ((Klanova et al., 2006; Klanova et al., 2007; Cupr et al., 2006)) confirmed that PAS are sensitive enough to mirror even small-scale differences, which makes them capable of monitoring spatial, seasonal and temporal variations. Passive samplers can be used for point sources evaluation on the scale of several square kilometers or less - from the local plants to diffusive emissions from transportation vehicles or household incinerators - as well as for evaluation of diffusive emissions from secondary sources. While insensitive to temporally short accidental releases, passive air samplers are suitable for measurements of long-term average concentrations at various spatial and time scales.

Passive air samplers consisting of the polyurethane foam disks (15 cm diameter, 1.5 cm thick, density 0.030 g cm⁻³, type N 3038; Gumotex Breclav, Czech Republic) housed in the protective chambers are employed. Sampling chambers were pre-washed and solvent-rinsed with acetone prior to installation. All filters were pre-washed, cleaned (8 hours extraction in acetone and 8 hours in dichloromethane), wrapped in two layers of aluminum foil, placed into zip-lock polyethylene bags and kept in the freezer prior to deployment. Exposed filters were wrapped in two layers of aluminum foil, labeled, placed into zip-lock polyethylene bags and transported in coolers at 5 °C to the laboratory where they were kept in the freezer at –18 °C until the analysis. Field blanks were obtained by installing and removing the PUF disks at all sampling sites. Figure 4.4 show the spatial distribution of the sampling sites covered under MONET Africa programme. Additional information on the sampling sites is given in Annex D, Table D5.

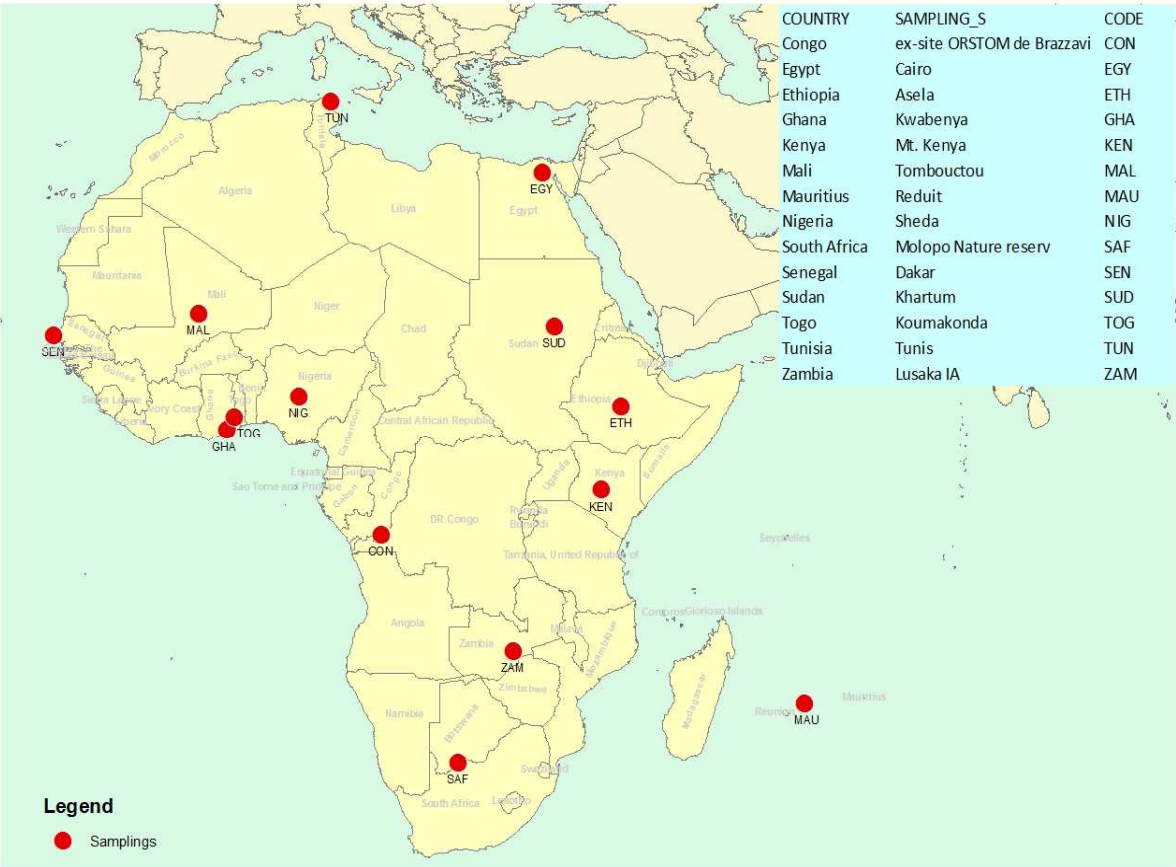


Figure 4.4 : MONET-AFRICA Sampling sites - pilot phase 2008

4.1.2.4. Sample analytical procedures

All samples were extracted with dichloromethane in a Büchi System B-811 automatic extractor. One laboratory blank and one reference material were analyzed with each set of ten samples. Surrogate recovery standards (*d8*-naphthalene, *d10*-phenanthrene, *d12*-perylene for PAHs analysis, PCB 30 and PCB 185 for PCBs analysis) were spiked on each filter prior to extraction. Terfenyl and PCB 121 were used as internal standards for polyaromatic hydrocarbon (PAH) and polychlorinated biphenyl (PCB)/organochlorine pesticide (OCP) analyses, respectively. Volume was reduced after extraction under a gentle nitrogen stream at ambient temperature, and fractionation achieved on a silica gel column; a sulphuric acid modified silica gel column was used for PCB/OCP samples. Samples were analyzed using GC-ECD (HP 5890) supplied with a Quadrex fused silica column 5% Ph for PCBs: PCB 28, PCB 52, PCB 101, PCB 118, PCB 153, PCB 138, PCB 180, and OCPs: α -hexachlorocyclohexane (HCH), β -HCH, γ -HCH, δ -HCH, 1,1-dichloro-2,2-bis (p-chlorophenyl)ethylene (*p,p'*-DDE), 1,1-dichloro-2,2-bis (p-chlorophenyl) ethan (*p,p'*-DDD), 1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethan (*p,p'*-DDT), *o,p'*-DDE, *o,p'*-DDD, *o,p'*-DDE, hexachlorobenzene (HCB), and pentachlorobenzene (PeCB). 16 US EPA polycyclic aromatic hydrocarbons were determined in all samples using GC-MS instrument (HP 6890 - HP 5972) supplied with a J&W Scientific fused silica column DB-5MS.

4.1.2.5 Quality Assurance and Quality Control

Recoveries were determined for all samples by spiking with the surrogate standards prior to extraction. Amounts were similar to detected quantities of analytes in the samples. Recoveries were higher than 76 % and 71 % for all samples for PCBs and PAHs, respectively. Recovery factors were not applied to any of the data. Recovery of native analytes measured for the reference material varied from 88 to 103 % for PCBs, from 75 to 98 % for OCPs, and from 72 to 102 % for PAHs. Laboratory blanks were under the detection limits for selected compounds. Field blanks consisted of pre-extracted PUF disks and they were taken on each sampling site. They were extracted and analyzed in the same way as the samples, and the levels in field blanks never exceeded 3% of quantities detected in samples for PCBs, 1% for OCPs, and 3% for PAHs, indicating minimal contamination during the transport, storage and analysis.

4.1.2.6 Generation of back trajectories

Trajectories were generated using the HYSPLIT model of the American National Oceanic and Atmospheric Administration, NOAA (NOAA, 2003). Three-dimensional four day back trajectories were generated for individual sampling intervals. The trajectories were generated every four hours of the sampling interval. The main output of the HYSPLIT model are geographical coordinates indicating the location of hourly trajectory segment endpoints. As the trajectories are calculated 96 hours back in time, each one in the map is usually defined by 96 segment endpoints.

The trajectories were generated at a starting height of 200 m above ground level. This level ensures that the trajectory starts in the mixing layer of the atmosphere. Additional control on this condition was conducted, and only sporadic trajectories were found to have their starting height above the mixing layer height during night. During previous days, the starting heights of all trajectories were well within the mixing layer, and no trajectory was excluded from the data set. However, since pollutant sources are mainly in the mixing layer, the trajectory changes its height and can reach heights above it when going back in time. In such cases, trajectory segments above this layer were excluded.

4.1.2.7. Data comparability

All samples collected from the MONET Africa pilot study were analysed in the same laboratory at RECETOX, in the Czech Republic to ensure that the data can be compared spatially and temporally. Data comparability between the air monitoring programmes in the region was evaluated using data from parallel samplers located at an existing station in Kostice, Czech Republic.

4.1.2.8. Sample and data storage

Sample extracts were capped tightly in Gas Chromatography vials and stored in a freezer at a temperature of about -20°C. Air concentration results and relevant sample information (such as Sample ID, site ID, location name, sample duration, meteorological conditions etc.) are recorded in excel spreadsheets.

4.2 PROGRAMS/ACTIVITIES RELATED TO HUMAN MILK

POPs monitoring data on human milk were provided by WHO from the samples submitted during the 3rd and the 4th rounds of WHO milk surveys. The 3rd round data was for the pooled sample submitted by Egypt, whereas the 4th data was for the sample from Sudan. Additional milk data was expected from UNEP- WHO milk survey conducted in 2008.

4.2.1. WHO survey of Human Milk for Persistent Organic Pollutants

4.2.1.1. Key message

POPs monitoring data on human milk were provided by WHO, from the 3rd and 4th rounds of WHO human milk survey activities.

4.2.1.2. Background

Since the mid-seventies, WHO in collaboration with UNEP has implemented the food component of the Global Environment Monitoring System (GEMS/Food), which collects, collates and evaluates data on the levels and trends of contaminants in food and human milk. These contaminants include the organochlorine pesticide POPs, which were the initial focus of attention. Beginning in the mid-eighties, WHO coordinated several surveys of the levels of dioxin-like polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). These surveys were carried out in collaboration with other international organisations and national institutions, and concentrated particularly on the health risk of infants, due to exposure through contaminated human-milk, and aiming to prevent and control exposure to these chemicals through food.

More recently, the WHO protocol for these surveys has been revised to include the objective of providing accessible, reliable and comparable data on levels of POPs in human milk for purposes of the Stockholm Convention. The latest protocol (used for the ongoing 4th survey) is different from the early protocol because it: a) emphasizes the protection, promotion and support of breastfeeding; b) specifies a minimum of 50 donors for one pooled sample, and; c) includes the analysis of all 12 POPs currently covered by the Convention. The latest version of WHO Guidelines (1 October 2007) is currently available at: <http://www.who.int/foodsafety/chem/POPprotocol.pdf>

4.2.1.3. Sampling

In order to promote reliability and comparability, participating countries are encouraged to adhere as closely to WHO protocol as much as possible. However, it is also recognized that the situations in countries vary considerably so that some flexibility is required. However, guidance is provided to assist countries in developing their national protocols, including:

Number of donors: A minimum of 50 individual donors should each provide 50 ml of human milk for preparing the pooled sample. Note that one additional participant per million population over 50 million is recommended for large countries and in some cases, more than one pooled sample may need to be prepared. On the other hand, a lower number samples may be necessary for small countries.

Strategies for selecting donors: Interviewing of potential donors can take place pre- or post-natal or in well-baby clinics. The stratification of donors should represent the presumed national exposure profile of each country. This would include consideration of diet, occupational exposure, rural and urban residence and proximity to potential POPs releasing sources such as industries and waste sites.

Biosafety: In general, the handling of any milk sample should comply with biosafety rules to protect workers who will handle samples. The National Coordinators should decide whether HIV-positive donors can participate in the survey.

Consequently, the sampling protocol will vary among countries and therefore, comparison of results between countries should be approached with caution. However, once the national protocol is established, it should be applied in subsequent rounds so that changes/trends can be followed. In these cases, observation of temporal trends should be scientifically valid provided information on the distribution of levels in individual samples is available.

4.2.1.4. Sample analytical procedures

a) Procedure for PCDDs, PCDFs and PCBs

After freeze-drying of the whole sample, fat and contaminants of interest are extracted in a hot extraction device ("Twisselmann extractor") with cyclohexane/toluene (50/50) for 8 hrs. After evaporation of the solvent, an aliquot of fat is spiked with ¹³C-labeled internal standards (17 PCDD/Fs, 5 non-ortho PCBs [37, 77, 81, 126, 169], 6 mono-ortho PCBs [28, 60, 105, 118, 156, 189] and 7 di-ortho PCBs [52, 101, 153, 138, 180, 194 and 209]). Gel permeation chromatography on Bio Beads S-X3 removes fat. A silica column impregnated with sulfuric acid removes remaining oxidizable substances. A florisil column separates PCDD/F from PCBs. The PCDD/F-fraction is purified on a Carbopack C-column. After addition of 1,2,3,4-¹³C12-TCDD, determination is performed by HRGC/HRMS (Fisons Autospec; resolution 10,000; DB5-MS). The PCBs are separated on a Carbopack B-column into three fractions of first di-ortho PCBs (elution with hexane), then mono-ortho PCBs (elution with hexane/toluene; 92.5/7.5) and finally non-ortho PCBs (reversed elution with toluene). After addition of ¹³C12-PCB 80, the different PCB groups are determined by HRGC/HRMS (Fisons Autospec; resolution 10,000; DB5-MS) in three separate runs. Marker PCBs are PCB 28, 52, 101, 138, 153 and 180.

b) Procedure for POP pesticides

The milk samples were analysed for the POP pesticides including aldrin, dieldrin, sum of chlordane, sum of DDT, sum of endrin, sum of heptachlor, hexachlorobenzene (HCB), mirex, and toxaphene (Polar congeners). Fats and POPs of interest were extracted from freeze-dried human milk as described above for PCDDs, PCDFs and PCBs. Up to 0.5 g of the fat extract was re-dissolved in cyclohexane/ethyl acetate and the internal standards (2,4,5-Trichlorobiphenyl and Mirex), dissolved in cyclohexane, were added. The applied clean up-parts of the analytical method followed the principles of the European standardised methods for pesticide residue analysis for fatty food - Determination of pesticides and PCBs", EN 1528 part 1-4, 1996-10 (confirmed 2001). To remove fat, gel permeation chromatography was performed on a chromatography column using Bio-Beads S-X3 with cyclohexane/ethyl acetate as eluting solvent. After concentration and transfer into iso-octane, chromatography on a small column of partially deactivated silica gel was used as final clean up steps with toluene as eluent.

Determination was performed with GC/ECD using a GC (Fisons Mega 2) with two parallel columns of different polarity (fused silica no. 1:30 m PS-088 [97.5% Dimethyl -2.5% diphenyl siloxane copolymer] 0.32 mm id., 0.32 µm film thickness, fused silica no. 2:30 m OV-1701-OH, 0.32 mm id., 0.25 µm film thickness, both columns customs column made). Results were confirmed by GC-LRMS (GC: HP 6890 / MS: HP 5973; 30 m HP5-MS, 0.25 mm id., 0.25 µm film thickness + 2.5 m pre-column; detection mode: MSD –EI). The limit of quantification (LOQ) was 0.5 ngg⁻¹ fat.

4.2.2.5. Data comparability

To ensure reliability of exposure data and to improve comparability of analytical results from different laboratories, WHO has coordinated a number of inter-laboratory quality assessment studies. A study on levels of PCBs, PCDDs and PCDFs in human milk was conducted between February 1996 and April 1997, with the objective of identifying laboratories whose results could be accepted by WHO for exposure assessment studies. Only the State Institute for Chemical and Veterinary Analysis of Food Freiburg met all the pre-set criteria for analyses of PCDDs, PCDFs, dioxin-like PCBs, marker PCBs and fat in human milk and was thus selected as the WHO Reference Laboratory for the third and fourth round of the WHO human milk studies.

As noted above, the protocol for collection of samples may vary from country to country and therefore, data comparability between countries is not advised without a review of the national protocols. However, temporal trends should be possible based on the use of a consistent protocol for collection and handling of samples and on stringent criteria to assure analytical quality assurance and control over long periods of time.

It should also be noted that the calculation of levels of PCDDs, PCDFs and dioxin-like PCBs may be slightly different for earlier surveys which use international toxic equivalence factors (I-TEQs) in comparison to the more recent surveys which use WHO toxic equivalence factors (WHO-TEQs). However, the levels reported for the earlier surveys should only be considered indicative of exposures because of the limited sampling plan and therefore, the differences between I-TEQs and WHO-TEQs are not considered to be minor.

4.2.2.6. Data storage

Data are stored at the GEMS/Food database located at WHO in Geneva, Switzerland and is password-accessible through the WHO Summary Information and Global Health Trends (<http://SIGHT>) portal.

4.3 PROGRAMS/ACTIVITIES RELATED TO OTHER MEDIA

4.3.1. Key message

A survey of literature reports showed that research work is being done within the African region on the contamination of water, soil, sediments, and food by pesticides with a focus on organochlorine pesticides including POP pesticides. The interest in POPs seems to have been enhanced in a certain extent due to sensitization brought up by the Stockholm Convention. However, the survey undertaken did not help identify any national or regional established monitoring program that specifically target POPs levels and temporal trends either in core media or in other media, at least to the knowledge of the information collected by the ROG. In this report, the Region decided to incorporate some monitoring data dealing with the contamination of water, soil, sediments, and food (other media) by POP pesticides in order to show that the African region does host some relevant technical infrastructure and effective expertise that need to be strengthened to help Africa participate fully in future Effectiveness Evaluations.

4.3.2. Background

In the African region, the issue of POPs is undoubtedly a recent one as revealed by many countries that have elaborated their National Profiles for chemicals management and/or developed their National Implementation Plans (NIPs) under the Stockholm Convention. Certain knowledge does exist in the region on hazardous pesticides including POPs. Hence, researchers from different institutions either individually or as teams have conducted some monitoring activities on POP pesticides. However, very little was known in Africa about PCBs dioxins and furans before the issues of the adverse effects of such compounds on humans and the environment was raised by the Stockholm Convention. Thus, there are few available data dealing with PCBs contamination and no monitoring data seemed to be recorded in the region on PCDDs/PCDFs. The ROG decided to include in this regional report only monitoring data on POP pesticides retrieved from the relevant literature, based on scientific papers published in international high level journals covering the time period recommended within the framework of this first evaluation. Some data could be found on human milk and blood, but those on human milk were recorded using a procedure that was not consistent with the WHO methodology.

4.3.3. Sampling

A variety of matrices have been analyzed with different sampling methodologies. In most cases sampling methodologies described in the papers do not clearly refer to international standard methodologies.

4.3.4. Sample analytical procedures

Most the publications reviewed do not mention QA/QC requirements, but all the papers selected for inclusion in this report used state-of the art equipment, especially GC and GC/MS with the conventional electron capture detector. Matrix samples were extracted using common organic solvents often as mixtures thereof, the solvent evaporated, the residue properly cleaned and handled as appropriate and finally analyzed. The analytes were identified through the use of authentic standards.

4.3.5. Data comparability

The monitoring data on soil, sediments, water, and food presented in this report cannot be compared across sites as they were not obtained from harmonized protocols/programs, and in addition have been recorded for different time periods.

4.3.6. Data storage

The only way the data selected can be considered as being stored to a certain extent, is that they were published in scientific journals and as such are available and could be consulted based on the references of the individual journals. It is not evident that the original laboratories that produced the results do have data bases for convenient analytical data storage. Indeed, it should be noted that there was no information on whether those laboratories were accredited or not.

5. RESULTS

Effectiveness evaluation is partly based on the examination of monitoring data that are expected to provide information on levels, trends and long-range transport of POPs. However, due to data shortage as a result of the absence of any established regional monitoring program on POPs, the contribution of the African region to this first evaluation is limited to information on levels of POPs.

This report presents a compilation of POPs monitoring data in the African region. Africa gathered comparable data on core media (ambient air and human milk) through activities conducted in collaboration with strategic partners (RECETOX and WHO). Along with these comparable results, additional non comparable monitoring data on levels of POPs in other media (water, sediments, soil, and foodstuff) retrieved from published scientific papers are provided as indicated in section four above. The comparable data on core media were collected within a relatively short period of time and the region could not provide information either on temporal trends of POPs levels in the core media or on their long-range transport.

5.1. POPs LEVELS IN AMBIENT AIR

The contamination of the ambient air by hazardous chemicals including POPs in Africa was first surveyed in a limited extent by the GAPS in four countries (Ghana, Egypt, Malawi, and South Africa) from 2005 to 2008 (Figure 4.1). The MONET-AFRICA -RECETOX ambient air sampling program, which was the second ambient air monitoring in the region, started as a pilot project in January 2008 and had a wider and more inclusive geographical coverage as it was deployed in 15 countries with a total of 25 sites (Figure 4.4). The use of different methodologies (sampling technique and/or exposure time) does not provide monitoring data comparability between GAPS and MONET Africa programmes.

5.1.1 Data from GAPS Network

Sampling conducted by the GAPS was discontinuous throughout the sampling year either in participating countries or at individual sampling sites (Figure 4.1). The monitoring data cover only years 2005 and 2006. POP analytes included: Chlordane group, DDTs, dieldrin, heptachlor group, and polychlorinated biphenyls (PCBs). The discontinuous sampling restricts the usefulness of the information on the concentration of

these compounds in ambient air (Annex E Table E1) in terms of baseline concentrations and time trends in both two sampling years.

5.1.1.1. Results from the PUF-disk PAS

Air concentrations (pg/m³) during each of the four sampling periods were recorded for selected target chemicals. Those listed under Annexes A, B and C of the Stockholm Convention [*cis*-chlordane (CC), *trans*-chlordane (TC) and *trans*-nonachlor (TN); *p,p'*-dichlorodiphenyltrichloroethane (DDT) and *p,p'*-dichlorodiphenyldichloroethylene (DDE); dieldrin; heptachlor (HEPT) and heptachlor epoxide (HEPX); polychlorinated biphenyls (PCBs)] are reported in Annex E Table E1.

5.1.1.2. Results from the XAD-based PAS

Results on the sampling lengths and the sequestered amounts of selected OCPs in ng/PAS and in pg/m³ were recorded. The concentrations of the pesticides that are classified under the Stockholm Convention [CC, TC, TN, DDT, DDE, dieldrin, HEPT, and HEPX] were assessed (AnnexE Tables E2 and E3).

5.1.2. Data from MONET –AFRICA-RECETOX

The partnership established between Africa and RECETOX involve 15 countries in a pilot project on ambient air monitoring which covered two sampling periods (January –March and April-June) during the first six months of the year 2008. The use of a harmonized sampling methodology (passive air sampling) gave comparable data on the levels POPs in the region. Along with these results on current POPs, useful information on the contamination of the ambient air by persistent toxic substances (polycyclic aromatic hydrocarbons: PAHs) currently not listed as POPs under the Convention was provided (Annex E Tables E4 to E61). While a comparison of the levels was of effective relevancy, temporal trends analysis could not be undertaken due to the short duration of the sampling (6 months).

5.1.2.1. Ambient air levels of POP pesticides listed in Annexes A and B of the Convention

5.1.2.1.1. Ambient air levels of Aldrin (January –July, 2008)

The levels of Aldrin detected in African countries are shown in Figures 5.1a and Table 5.1 below. The figure shows that the highest levels of aldrin were measured in air samples from Egypt.

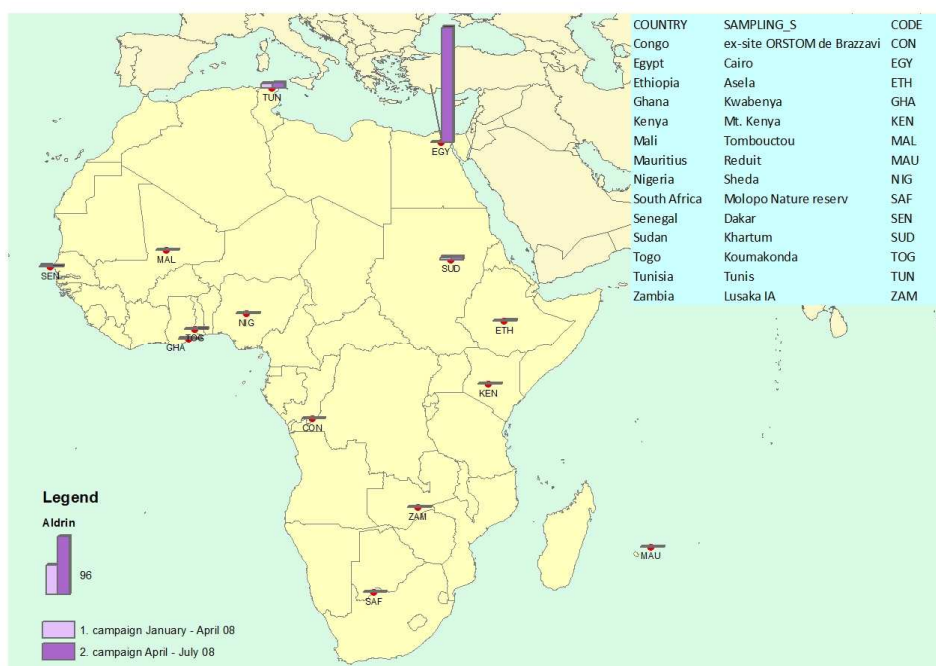


Figure 5.1a: Aldrin levels in the ambient air (PAS, ng filter-1) in Africa, January-July, 2008

Table 5.1: Statistical evaluation of pesticide concentrations determined in the passive air Samples

Country	Aldrin		Dieldrin		Endrin	
	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MIN ng filter ⁻¹	MAX ng filter ⁻¹
Congo	<LOQ	<LOQ	2.2	26.0	<LOQ	<LOQ
Egypt	<LOQ	191.5	<LOQ	2.2	9.4	10.0
Ethiopia	<LOQ	1.4	<LOQ	1.4	<LOQ	<LOQ
Ghana 01	<LOQ	1.1	2.2	3.3	<LOQ	<LOQ
Kenya 01		<LOQ		0.5		<LOQ
Mali 01	<LOQ	<LOQ	<LOQ	0.3	<LOQ	<LOQ
Mauritius	<LOQ	<LOQ	1.4	1.7	<LOQ	<LOQ
Nigeria	<LOQ	<LOQ	<LOQ	0.8	<LOQ	<LOQ
South Africa 01	<LOQ	0.2	<LOQ	0.2	<LOQ	<LOQ
Senegal	0.7	2.0	41.0	52.0	<LOQ	<LOQ
Sudan	3.7	4.8	0.6	3.0	1.8	2.4
Togo	<LOQ	0.3	<LOQ	2.7	<LOQ	<LOQ
Tunisia	7.4	9.0	1.3	1.3	<LOQ	<LOQ
Zambia		<LOQ		7.2		<LOQ

Figures 5.b below shows the levels of aldrin measured in the region excluding Egypt. From the figure, other countries with high levels of aldrin were Tunisia, Sudan and Senegal.

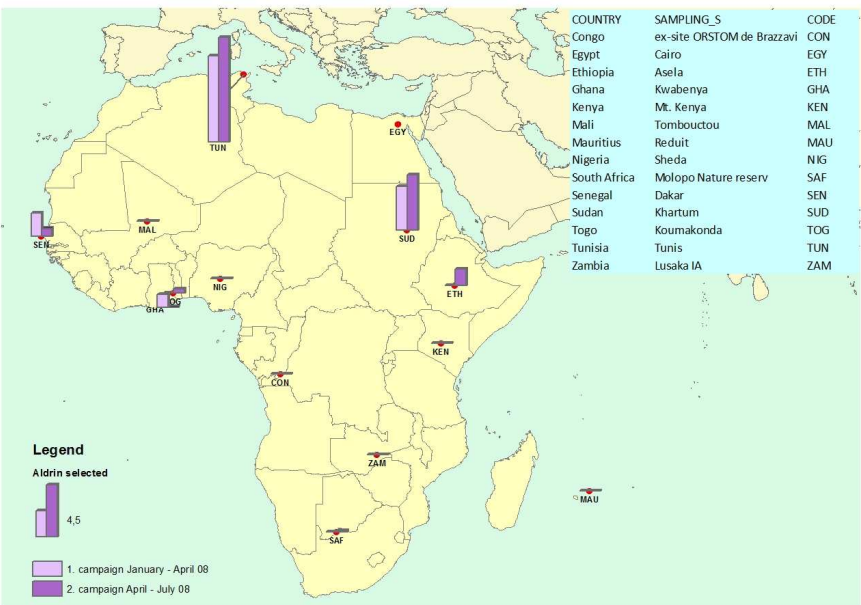


Figure 5.1b: Aldrin levels in the ambient air (PAS, ng filter-1) in Africa (Egypt excluded), January-July, 2008

Figure 5.1c shows the levels of isodrin, an isomer of aldrin, detected in air from African countries. The highest concentration of Isodrin were detected in Senegal and Sudan.

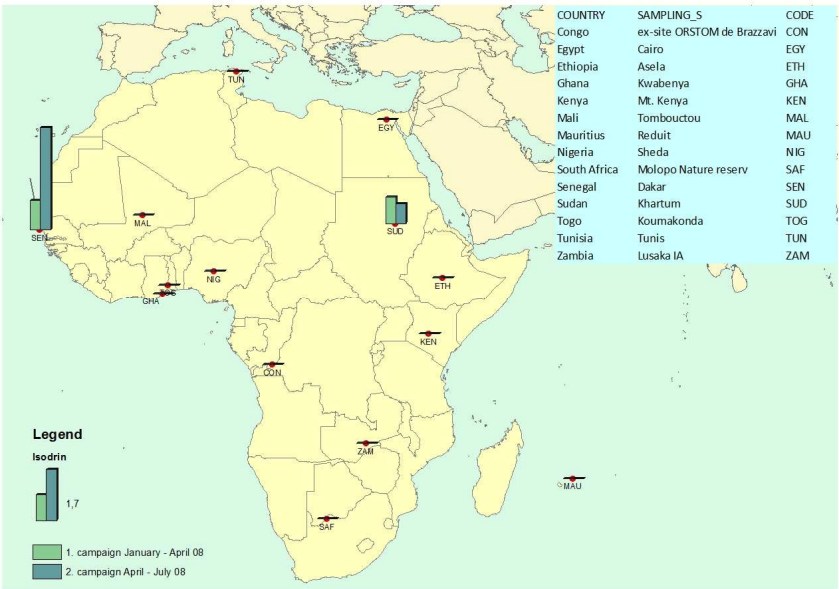


Figure 5.1c: Isodrin levels in the ambient air (PAS, ng filter-1) in Africa, January-July, 2008

5.1.2.1.2 Ambient air levels of DDTs (January –July, 2008)

The levels of DDT and its metabolites (level expressed as: sum of o,p'- and p,p'-DDT, DDE, DDD) in ambient air recorded throughout the 6-month sampling period at the various sampling sites are shown in Figures 5.2a below.

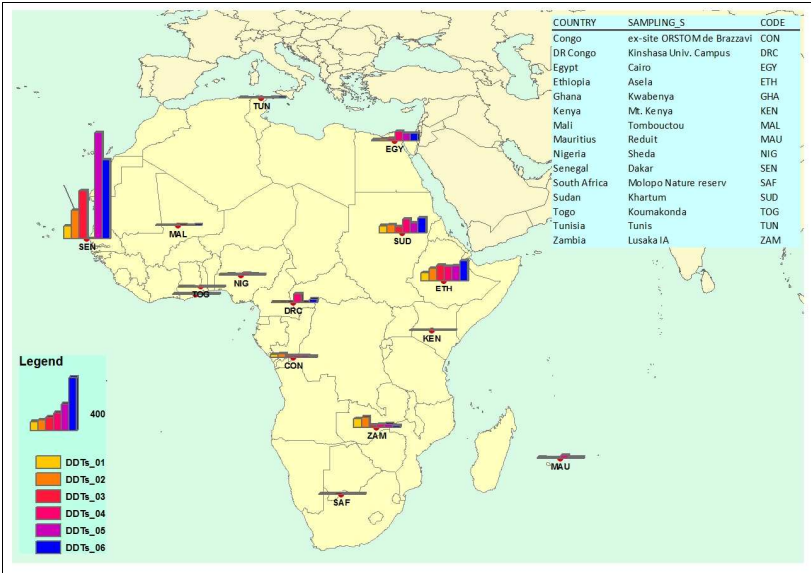


Figure 5.2a: DDT levels (sum of o,p'- and p,p'-DDT, DDE, DDD) in the ambient air (PAS, ng filter⁻¹) in Africa, January-July, 2008

The concentrations of DDT in African countries excluding Senegal are shown in Figure 5.2b. The levels varied from one country to another.

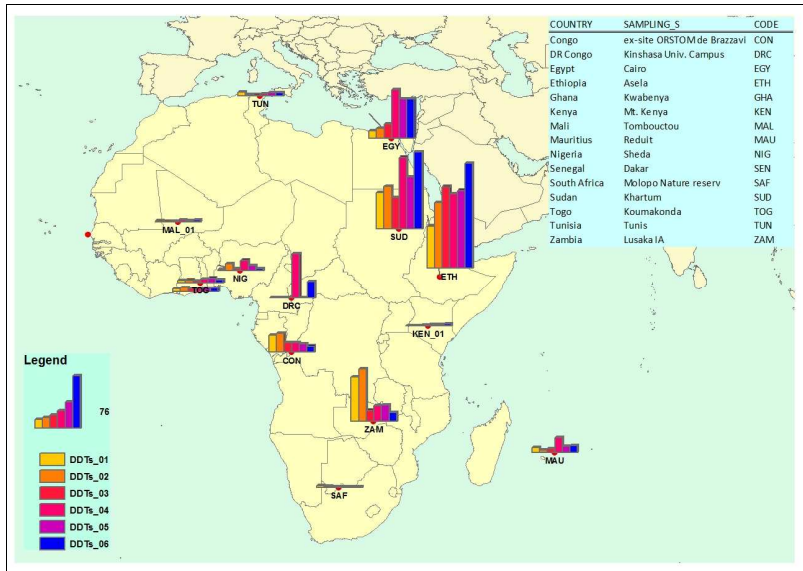


Figure 5.2b: DDT levels (sum of o,p'- and p,p'-DDT, DDE, DDD) in the ambient air (PAS, ng filter⁻¹) in Africa (Senegal excluded), January-July, 2008

DDT concentrations in most samples ranged between tens and hundreds of pg m^{-3} for the sum of DDTs while there were also a few samples with concentrations above 1 ng m^{-3} . DDT levels in samples from the background sites measured under the GAPS study were in tens of pg m^{-3} which correspond with the background levels found in this study.

The maxima, minima and median levels of DDT for each of the sampling sites are shown in Table 5.2 below. The actual concentrations detected in each country are given in Annex Tables E4 to E29. The highest air levels (median of $2584 \text{ ng filter}^{-1}$, maximum $8970 \text{ ng filter}^{-1}$) were found at Kitengela pesticide dump site. Other sampling sites with hundreds of nanograms of DDT per filter were found in Ethiopia, Mali, Sudan and Senegal. The lowest concentrations ($1\text{-}2 \text{ ng filter}^{-1}$) were found at Mount Kenya, Tombouctou in Mali and background sites in South Africa (Table 5.2).

Table 5.2: Statistical evaluation of DDT concentrations determined in the passive air samples

DDTs	MIN ng filter^{-1}	MAX ng filter^{-1}	MEAN ng filter^{-1}	MEDIAN ng filter^{-1}
Congo	8.9	27.7	16.9	14.3
DR Congo	19.5	85.6	44.7	36.5
Egypt	10.6	70.1	38.3	38.9
Ethiopia	61.5	152.4	108.1	110.6
Ghana 01	4.5	6.1	5.2	5.1
Ghana 02	7.9	20.6	12.1	10.5
Kenya 01	1.3	2.4	1.9	2.0
Kenya 02	3.5	12.6	7.7	7.1
Kenya 03	1969.8	8969.9	3979.4	2584.4
Kenya 04	19.8	98.6	54.2	48.7
Kenya 05	14.7	40.1	25.0	20.1
Mali 01	0.6	3.0	1.8	1.8
Mali 02	68.6	163.8	113.1	101.4
Mali 03	2.8	139.2	37.7	15.4
Mali 04	23.4	74.1	37.3	28.8
Mali 05	3.7	24.4	10.9	9.3
Mauritius	3.8	21.3	9.3	7.8
Nigeria	1.7	14.9	6.4	4.7
Senegal	92.7	796.9	410.9	359.2
South Africa 01	1.1	3.1	1.8	1.5
South Africa 02	1.0	5.5	2.9	2.1
South Africa 03	1.5	6.5	3.5	2.5
Sudan	45.2	111.9	75.3	68.8
Togo	2.8	6.5	4.6	4.5
Tunisia	1.5	5.7	3.4	3.4
Zambia	13.2	77.8	36.5	23.3

The DDE/DDT ratio in ambient air was very variable between the countries. DDE was more abundant in Congo, Ghana, Mali and Sudan, while DDT had higher concentrations in Ethiopia and Zambia. In Senegal and Kenya, levels of DDE and DDT were similar. The measured DDT concentrations in Kenya were high during the dry season.

Additional information, on the concentrations of DDT in soils collected from the air monitoring stations, is given in Annex Tables E30 and E31

5.1.2.1.3. Ambient air levels of Dieldrin (January –July, 2008)

The levels of Dieldrin in ambient air as measured during the sampling campaign are shown in Figures 5.3. The highest levels were detected in Senegal and Congo. The actual conetrations are shown in Table 5.1.

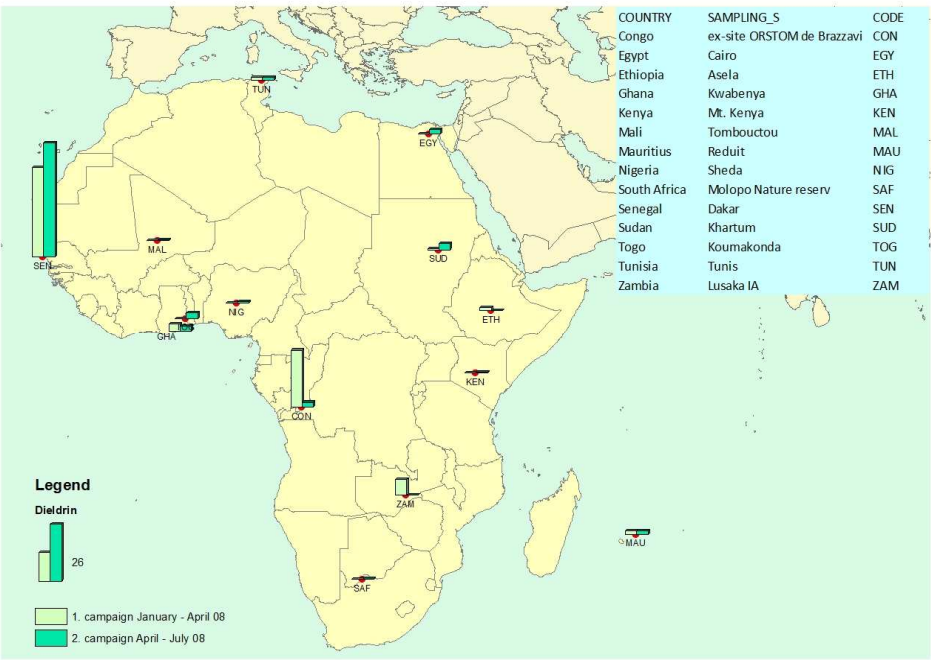


Figure 5.3: Dieldrin levels in the ambient air (PAS, ng filter⁻¹) in Africa, January-July, 2008

5.1.2.1.4. Ambient air levels of Endrin (January –July, 2008)

Endrin levels in ambient air at the sampling sites are shown in Figures 5.4a and 5.4b and Table 5.1.

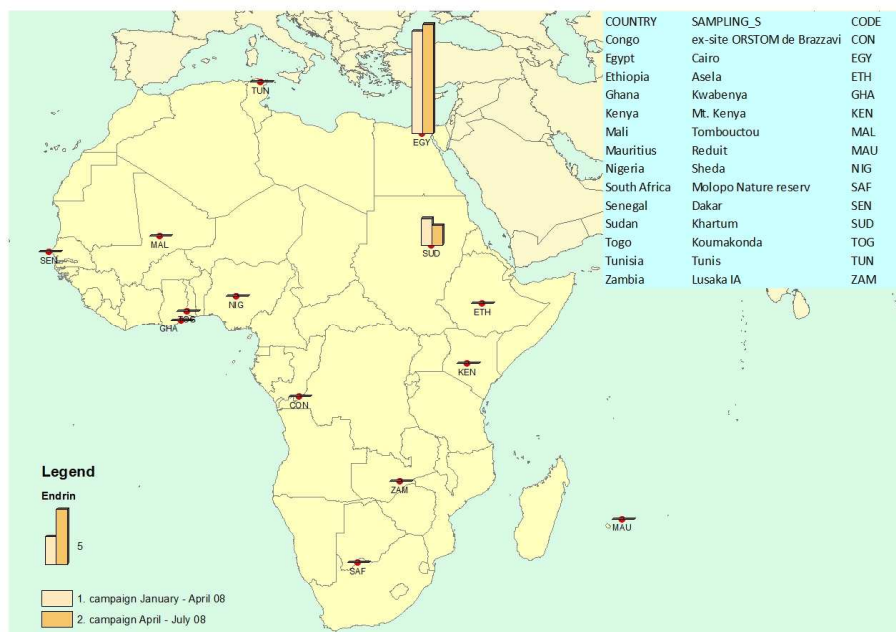


Figure 5.4a: Endrin levels in the ambient air (PAS, ng filter⁻¹) in Africa, January-July, 2008

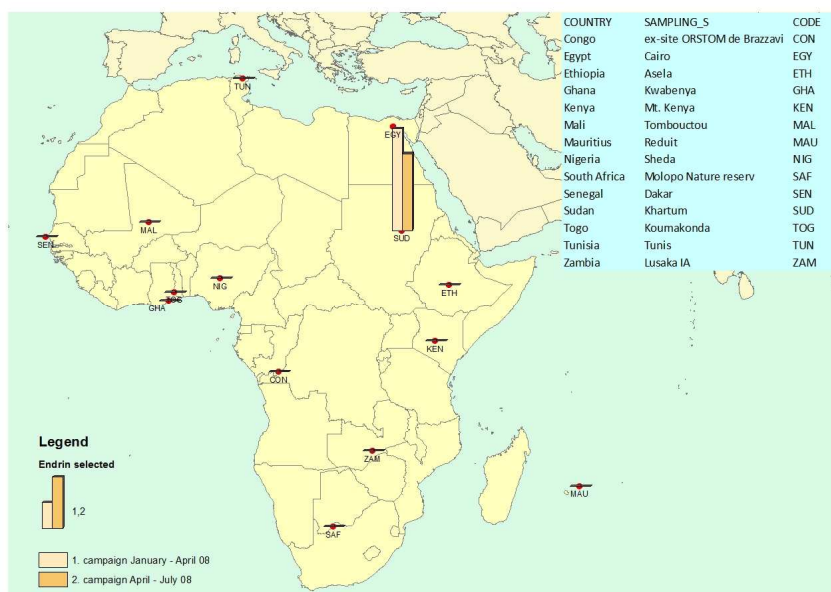


Figure 5.4b: Endrin levels in the ambient air (PAS, ng filter⁻¹) in Africa (Egypt excluded), January-July, 2008

5.1.2.1.5. Ambient air levels of Mirex (January –July, 2008)

Figure 5.5 below shows the levels of ambient air for the various sampling sites. The minimum and maximum concentration values are shown in Table 5.3.

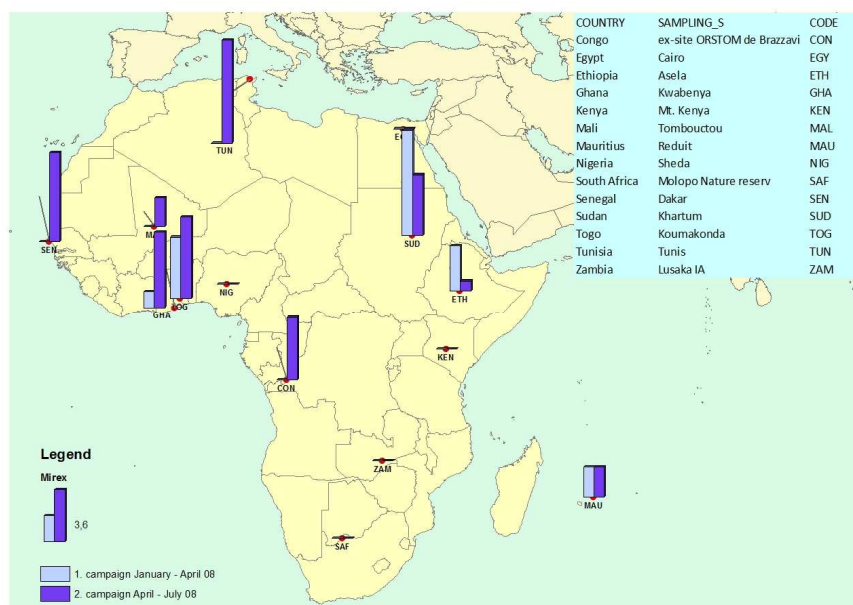


Figure 5.5: Mirex levels in the ambient air (PAS, ng filter⁻¹) in Africa, January-July, 2008

Table 5.3 Statistical evaluation of Mirex and Chlordanes concentrations determined in the passive air Samples

OCPs	Mirex		sum of chlordanes		sum of endosulfans	
	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MIN ng filter ⁻¹	MAX ng filter ⁻¹
Congo	<LOQ	4.3	<LOQ	<LOQ	40.0	97.4
Egypt	<LOQ	<LOQ	<LOQ	<LOQ	48.0	152.3
Ethiopia	0.7	3.1	<LOQ	6.2	143.6	275.0
Ghana 01	1.1	5.2	<LOQ	<LOQ	<LOQ	642.0
Kenya 01		<LOQ		<LOQ		2.3
Mali 01	<LOQ	2.0	<LOQ	1.6	<LOQ	24.0
Mauritius	2.0	2.0	<LOQ	<LOQ	<LOQ	35.2
Nigeria	<LOQ	<LOQ	<LOQ	1.7	<LOQ	44.0
South Africa 01	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	52.0
Senegal	<LOQ	6.1	2.0	22.8	321.0	353.7
Sudan	4.1	7.2	0.8	1.8	<LOQ	<LOQ
Togo	4.2	5.6	<LOQ	<LOQ	133.0	152.3
Tunisia	<LOQ	7.1	<LOQ	<LOQ	5.5	157.2
Zambia		<LOQ		8.9		46.0

5.12.1.6. Ambient air levels of chlordane (January-July, 2008)

The levels of Chlordane (sum of cis-chlordane, trans-chlordane and nonachlor) in the ambient air are indicated in Figure 5.6. The minimum and maximum values are shown in Table 5.3.

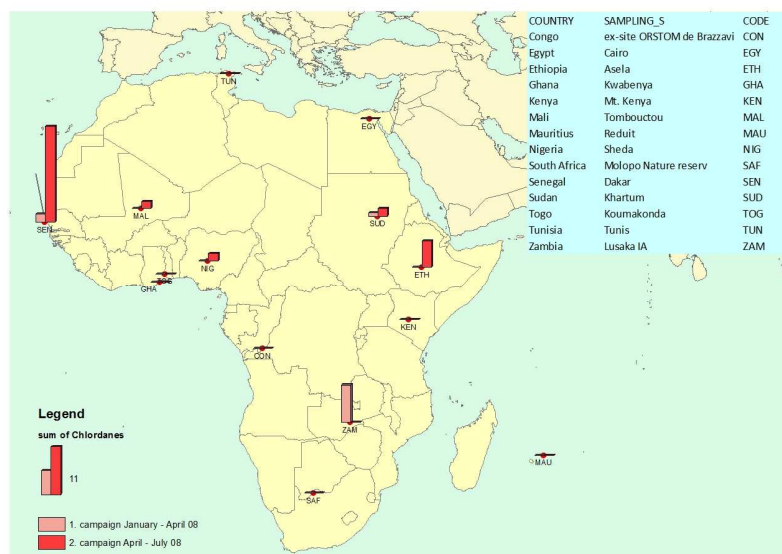


Figure 5.6: Chlordane levels (sum of cis-chlordane, trans-chlordane and nonachlor) in ambient air (PAS, ng filter⁻¹) in Africa, January-July, 2008

5.1.2.1.7. Ambient air levels of Heptachlor (January -July, 2008)

The levels of Heptachlor in ambient air at the sampling sites are illustrated by Figure 5.7. The highest levels of Heptachlor were detected in Egypt, Senegal and Sudan. The minimum and maximum levels are indicated in Table 5.4 below.

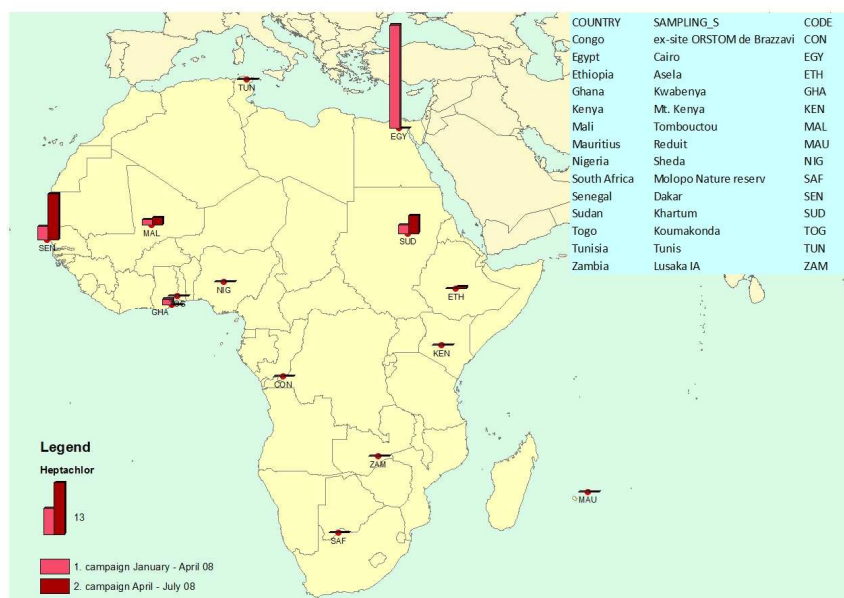


Figure 5.7: Heptachlor levels in the ambient air (PAS, ng filter-1) in Africa, January-July, 2008

Table 5.4 Statistical evaluation of Heptachlor, isodrin and Methoxychlor concentrations determined in the passive air Samples

OCPs	Heptachlor		Isodrin		Methoxychlor	
	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MIN ng filter ⁻¹	MAX ng filter ⁻¹
Congo	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Egypt	<LOQ	26.0	<LOQ	<LOQ	<LOQ	<LOQ
Ethiopia	<LOQ	0.6	<LOQ	<LOQ	<LOQ	<LOQ
Ghana 01	<LOQ	1.5	<LOQ	<LOQ	<LOQ	<LOQ
Kenya 01		<LOQ		<LOQ		<LOQ
Mali 01	1.3	1.9	<LOQ	<LOQ	<LOQ	<LOQ
Mauritius	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Nigeria	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
South Africa 01	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Senegal	3.4	11.6	1.0	3.5	<LOQ	42.2
Sudan	2.1	4.5	0.7	0.9	4.5	33.7
Togo	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Tunisia	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Zambia		<LOQ		<LOQ		<LOQ

5.1.2.1.8. Ambient air levels of Hexachlorobenezene (January –July, 2008)

The levels of Hexachlorobenezene (HCB) in ambient air recorded throughout the sampling campaign at the various sampling sites are shown in Figures 5.8a below. Hexachlorobenzene concentrations in air were low and uniform with the exception of Egypt where the levels were one order of magnitude higher than anywhere else. The actual concentrations of HCB per country are shown in Annex E Tables E 4 to E 26.

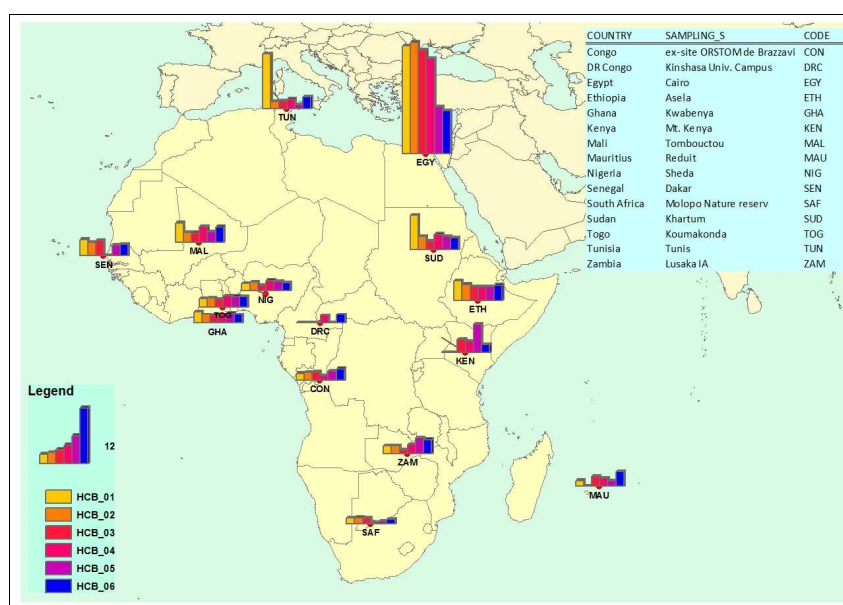


Figure 5.8a: HCB levels in the ambient air (PAS, ng filter⁻¹) in Africa, January-July, 2008

Table 5.5 below show the minimum, maximum, mean and median concentration of Hexachlorobenzene detected in ambient air.

Table 5.5: Statistical evaluation of HCB concentrations determined in the passive air samples

HCB	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹
Congo	1.0	2.5	1.7	1.8
DR Congo	0.9	2.9	1.7	1.6
Egypt	9.0	23.4	17.8	20.9
Ethiopia	2.8	4.1	3.2	3.1
Ghana 01	1.7	2.6	2.0	1.9
Ghana 02	1.2	2.8	1.7	1.5
Kenya 01	1.6	6.0	3.2	2.5
Kenya 02	0.4	2.3	1.5	1.8
Kenya 03	3.7	6.0	5.2	5.4
Kenya 04	3.6	4.6	4.2	4.2
Kenya 05	4.5	12.4	7.9	7.9
Mali 01	2.0	4.0	2.8	2.7
Mali 02	1.4	4.7	2.6	2.6
Mali 03	1.2	2.9	2.1	2.2
Mali 04	1.3	2.8	2.0	1.9
Mali 05	0.9	3.2	1.7	1.6
Mauritius	0.1	3.2	1.6	1.5
Nigeria	1.2	2.2	1.8	1.8
Senegal	2.3	3.4	2.8	2.8
South Africa 01	0.3	1.3	1.0	1.1
South Africa 02	0.1	2.0	1.1	1.0
South Africa 03	1.4	3.8	2.8	2.7
Sudan	1.8	7.3	3.4	2.8
Togo	1.6	2.3	2.0	2.0
Tunisia	0.8	11.6	3.3	1.8
Zambia	0.8	3.4	2.1	1.8

5.1.2.1.9. Discussion on statistics of ambient air levels of Annex A pesticides (January –July, 2008)

During the sampling campaign, eight out of nine Stockholm Convention Annex A pesticides (Annex A Table A2) were detected at levels quantifiable (Tables 5.1 to 5.5). These pesticides are: Aldrin, Chlordanes, Dieldrin, Endrin, Heptachlor, and Mirex. Along with these current POP pesticides, the sampling took into account some persistent toxic pesticides, such as endosulfan and HCHs (one these being Lindane currently recommended by the POPs Review Committee (POPRC) to the COP for listing in Annex A of the Convention)

Other pesticides were also analyzed in the two 3-months samples. Great variability between the levels of the individual pesticides in 14 countries was found. None of the selected countries had all pesticides below the quantification limit.

Aldrin was detected in Senegal, Sudan and Tunisia in the first campaign and in Egypt, Ethiopia, Ghana, South Africa and Togo in the second campaign. The only site with high levels was Cairo, Egypt, where the concentration reached 190 ng filter⁻¹ in the second sampling period. All the other sites were below 10 ng.

Dieldrin was detected in Congo, Ghana, Mauritius, Senegal, Sudan and Tunisia in the first campaign period and were found in all countries in the second period. The highest levels were measured in Senegal

(52 ng filter⁻¹, 85-170 pg m⁻³) and Congo (26 ng filter⁻¹, 45-90 pg m⁻³). Under the GAPS study, dieldrin was detected in Ghana, Malawi and South Africa with concentrations between 16 and 141 pg m⁻³.

Endrin, isodrin, heptachlor and metoxychlor were below the limit of quantification in most countries, and were found more frequently in the second sampling period. The only two countries where endrin was detected were Egypt and Sudan, levels in Egypt in the second period reached 10 ng filter⁻¹. Heptachlor had the highest levels in Egypt (26 ng filter⁻¹) and Senegal (12 ng filter⁻¹). Isodrin and metoxychlor were only found in Senegal and Sudan: isodrin levels were below 3.5 ng filter⁻¹, while metoxychlor reached 42 and 34 ng filter⁻¹ in Senegal and Sudan, respectively.

In the first sampling period, **mirex** was detected in four countries only (Ethiopia, Ghana, Sudan, Togo), while it was found at most sites in the second period. Levels, however, were below 7 ng filter⁻¹.

The sum of **chlordanes** (cis-chlordane, trans-chlordane and nonachlor) reached the highest levels in Senegal (23 ng filter⁻¹, 35-70 pg m⁻³), Zambia (9 ng filter⁻¹, 15-30 pg m⁻³) and Ethiopia (6 ng filter⁻¹, 10-20 pg m⁻³). Concentrations of the individual chlordanes at the background sites in the GAPS study were in units of pg m⁻³, and the highest sum was measured in Malawi (11 pg m⁻³).

Endosulfans (sum of I and II) were found to have the highest concentrations of all pesticides, with 645 ng filter⁻¹ in Ghana (1000-2000 pg m⁻³), 353 ng filter⁻¹ in Senegal (600-1200 pg m⁻³), and 275 ng filter⁻¹ in Ethiopia (450-900 pg m⁻³). In addition, they were over 100 ng filter⁻¹ in Egypt, Togo and Tunisia. This corresponds very well with the GAPS study where up to 3712 and 1417 pg m⁻³ of endosulfan I and II, respectively, were detected in samples from Ghana. Similar to the GAPS study, the levels were always significantly higher in the second sampling period.

5.1.2.2. Ambient air levels of industrial POPs listed in Annex A of the Convention (PCBs)

The analytes included in the monitoring of the industrial POPs were the seven indicator PCB congeners (PCB 28, PCB 52, PCB 101, PCB118, PCB 138, PCB 153, PCB 180). The highest median PCB level was found in the passive air samples from Dakar, Senegal (104 ng per filter with a maximum of 132 ng). It has been demonstrated before that the design of the sampler deployed for 28 days, collects the amount of chemicals equivalent to 100-200 m³ of air. It means that PCB level measured in Senegal represented ambient air concentrations of 500 pg to 1 ng m⁻³. PCB 153 was the most abundant of all the congeners analysed in these samples. Higher median levels were also found in Cairo, Egypt (42 ng filter⁻¹), and industrial sites in Kenya (36 ng filter⁻¹) and Kinshasa, Democratic Republic Congo (30 ng filter⁻¹ with the maxima of 102 ng). PCB 28 was prevalent in Kenya, especially in the samples collected from May to July 2008. All these sites were urban or industrial and measured levels corresponded to those measured at industrial sites in Europe. The lowest PCB levels (around 1 ng per filter) were measured at the background sites in Ethiopia, Mali, Mauritius, Kenya and South Africa, but also at the rural sites in Mali and Nigeria, while the urban sites in Congo, Ghana, Mali, Sudan or Tunisia had levels around 10 ng per filter.

The sum of the concentrations of the seven PCB congeners monitored throughout the 6-month monitoring campaign are shown in Table 5.6, and illustrated in Figures 5.9 below. The levels of PCB detected in each country over the six months are shown in Annex E Tables E4- E31.

Table 5.6: Statistical evaluation of PCB concentrations determined in the passive air samples

PCBs	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹
Congo	6.8	16.2	10.3	8.6
DR Congo	23.1	102.2	39.1	30.4
Egypt	25.3	46.4	38.8	41.6
Ethiopia	1.2	2.5	1.8	1.7
Ghana 01	8.2	12.6	10.1	9.7
Ghana 02	6.9	20.3	12.8	11.4
Kenya 01	0.7	2.4	1.4	1.3
Kenya 02	1.6	2.8	2.2	2.1
Kenya 03	3.0	5.8	4.8	5.0
Kenya 04	11.7	71.3	40.9	36.0
Kenya 05	22.2	34.7	26.0	24.7
Mali 01	0.7	3.2	1.2	0.8
Mali 02	14.9	26.1	20.0	19.4
Mali 03	3.5	25.6	12.0	9.7
Mali 04	2.0	5.0	3.7	3.9
Mali 05	0.9	2.8	1.4	1.2
Mauritius	1.1	3.5	1.8	1.7
Nigeria	1.4	12.9	3.7	1.5
Senegal	54.3	132.5	93.3	103.6
South Africa 01	0.8	6.1	1.8	1.2
South Africa 02	0.9	1.9	1.4	1.4
South Africa 03	1.0	4.5	3.1	3.1
Sudan	13.8	39.2	23.6	20.5
Togo	0.7	5.3	2.4	2.3
Tunisia	8.1	19.1	11.7	10.2
Zambia	1.5	7.9	3.5	2.5

PCB levels, from ones to hundreds of ng per filter, correspond to air concentrations between tens of pg and 1 ng m⁻³. This is in a good agreement with the GAPS study where PCB concentrations between 35 and 252 pg m⁻³ were found at background sites (there were however, more than 7 indicator congeners analyzed in the GAPS study).

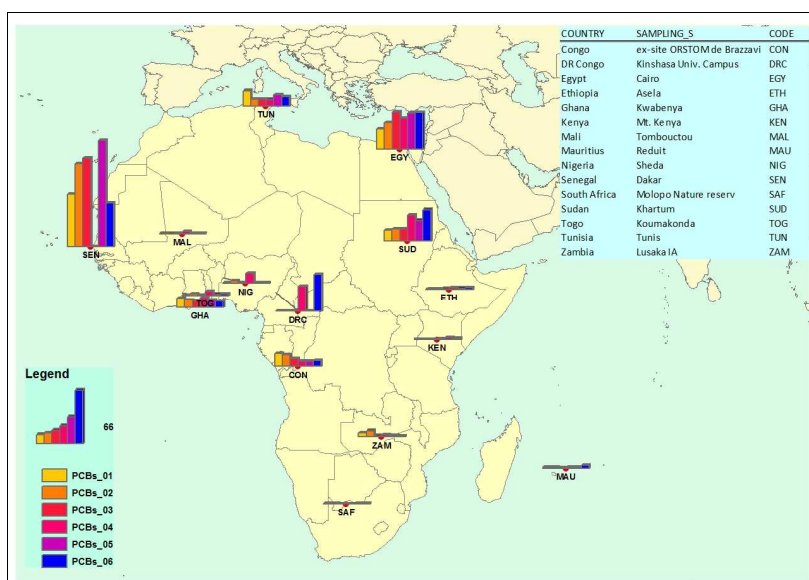


Figure 5.9: Sum PCB levels (7 indicator congeners) in the ambient air (PAS, ng filter⁻¹) in Africa, January-July, 2008

5.1.2.3. Unintentional POPs listed in Annex C of the Convention (PCDDs and PCDFs)

5.1.2.3.1. Levels of dioxins and furans in Africa (January –July, 2008)

As PCDDs/Fs concentrations were expected to be much lower, passive air samples for this analysis were collected for 3 months. PCDDs/Fs concentrations measured are shown in Table 5.7 below.

Table 5.7: Statistical evaluation of PCDDs/Fs concentrations determined in the passive air samples

PCDDs/Fs	sum of PCDDs		sum of PCDFs		I-TEQ	
	MIN pg filter ⁻¹	MAX pg filter ⁻¹	MIN pg filter ⁻¹	MAX pg filter ⁻¹	MIN pg I-TEQ filter ⁻¹	MAX pg I-TEQ filter ⁻¹
Congo	246.4	267.8	335.1	523.7	6.2	9.8
Egypt	5700.0	6550.0	30600.0	38300.0	505.5	616.7
Ethiopia	80.0	102.2	205.1	286.3	1.4	4.0
Ghana 01	373.2	1070.0	808.1	2149.9	11.9	33.8
Kenya 01		21.7		25.4		0.7
Mali 01	15.2	65.4	2.6	52.1	1.8	1.8
Mauritius	52.2	78.0	63.1	86.7	1.0	1.2
Nigeria	39.3	286.0	553.8	1200.0	2.0	9.3
South Africa 01	23.1	31.2	22.0	23.4	0.1	1.5
Senegal	2220.0	3430.0	4260.0	7310.0	59.2	79.4
Sudan	629.6	1130.0	923.4	1290.0	28.5	29.2
Togo	46.3	209.9	103.3	258.9	1.3	2.7
Tunisia	369.7	917.4	440.4	1200.0	6.7	19.0
Zambia		81.1		91.9		1.7

PCDD/F contamination of the air samples from Cairo, Egypt was at least one order of magnitude higher than in samples from any other site. It is probably connected to the industrial character of the site but especially to the frequency of combustion and open burning processes. I-TEQ concentrations in two 3-months samples were 505 and 616 pg of I-TEQ per filter (providing that the theoretical sample volume was 300-600 cubic meters in 3 months, these values should roughly correspond to the atmospheric concentrations around 1 pg of I-TEQ m⁻³). Concentrations of PCDFs in these samples were almost half an order of magnitude higher than concentrations of PCDDs. PCDD/F contamination in the range between 10 and 100 pg of I-TEQ per filter were also found at other industrial (Senegal) and urban (Ghana, Sudan and Tunisia) sites in this study. On the contrary, the lowest levels of PCDDs/Fs (around 1 pg of I-TEQ per filter) were found at Mt. Kenya, in Mauritius, Zambia or Tombouctou in Mali. As in the case of PAHs, partitioning between the gas and particle phases plays an important role for PCDDs/Fs as well. It is expected that PAS-derived PCDD/F concentrations are somewhat underestimated. This, however, deserves further investigation.

Figures 5.10a and 5.10b illustrate the levels of dioxins and furans in the region. The levels measured varied from one country to the other depending on the various socio-economic and industrial activities that characterize each country. Despite the fact that the data was collected over a short period of time, the results indicate the need for continuous monitoring of POPs in the region in order to acquire adequate data that can be used to evaluate the temporal and spatial trends of POPs in the region.

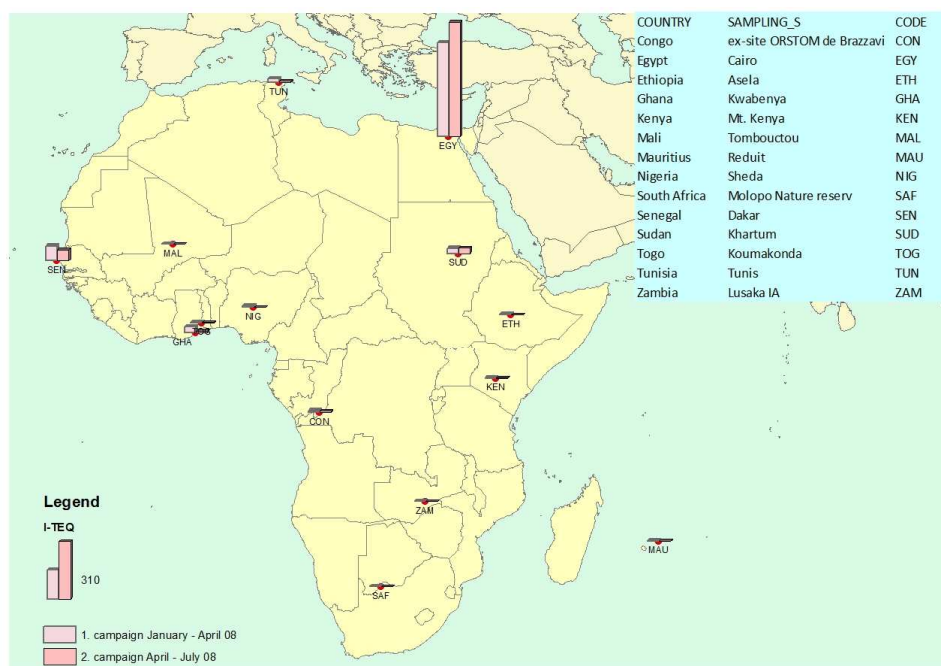


Figure 5.10a: PCDDs/Fs levels (I-TEQ) in the ambient air (PAS, pg filter⁻¹) in Africa, January-July, 2008

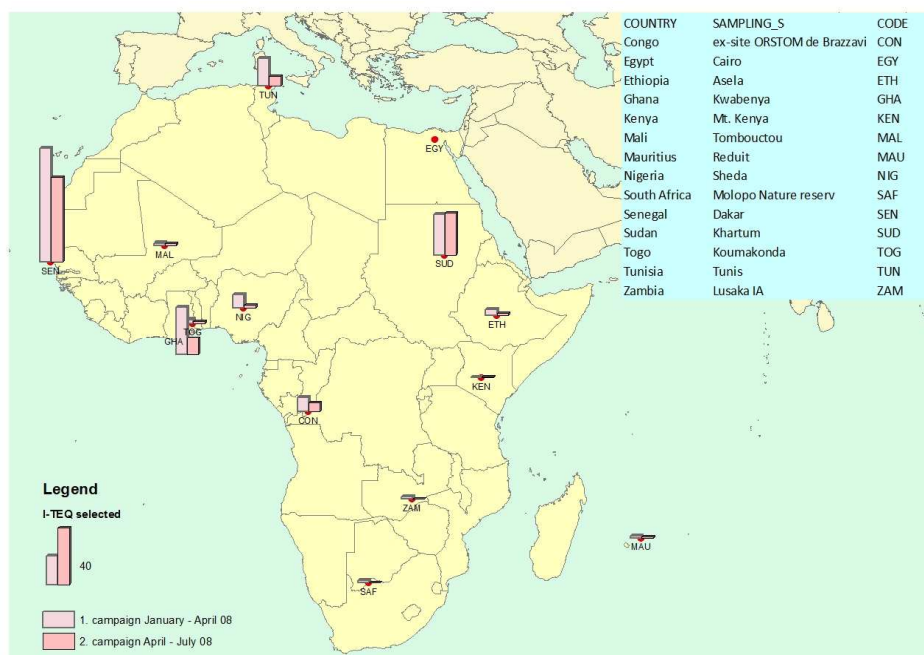


Figure 5.10b: PCDDs/Fs levels (I-TEQ) in the ambient air (PAS, pg filter⁻¹) in Africa (Egypt excluded), January-July, 2008

5.1.2.4. Discussion of POPs levels in ambient air in individual countries

Data collected during the sampling campaign and presented in this report give information on the levels of the twelve POPs currently listed under the Convention, but they also provide useful information on a number of persistent toxic substances not yet listed as POPs (HCHs, PAHs, endosulfan, and PAHs), some of which (Lindane, endosulfan) are currently being considered by the POP Review Committee for inclusion in the convention.

Kenya and Mali were the two countries selected for more detailed screening. Five sampling sites were selected in each of these countries with the goal of obtaining more information on the contamination gradients.

5.1.2.4.1. POPs levels in ambient air in Kenya

In Kenya, **Mt. Kenya** served as an African background (Annex E Figure 9). The sampling site is 3600 m above the sea level and the only possible source of POPs was long-range transport. Most of the time, this site provided samples with lowest (or one of the lowest) POPs concentrations in the whole campaign. This was true for PCDDs/Fs and PAHs, as well as for PCBs and DDTs. Levels of HCB were uniform in Africa and Mt. Kenya showed results similar to other sampling sites. The α -HCH/ γ -HCH ratio was variable with γ -HCH prevailing most of the time. Similarly, *p,p'*-DDT was prevalent in some campaigns and *p,p'*-DDT in others. From the selection of pesticides other than DDT and HCH, only traces of dieldrin and endosulfan were detected at Mt. Kenya. This site would serve well as a continental background for Africa in the follow-up studies.

Kabete is an urban background site approximately 25 km from Nairobi City. Possible sources of POPs could be agricultural activities and car emissions. PCBs were slightly higher than at Mt. Kenya, as were DDTs and PAHs. On the contrary, HCHs and HCB were found at lower levels. Levels of α -HCH were lower than those of γ -HCH, and *p,p'*-DDE was generally higher than *p,p'*-DDT. DDT and especially HCH contamination of air was significantly higher in March. PAH levels were lower between January and April than between April and July.

Kitengela site is an obsolete pesticide storage facility where evaporation from the old burdens caused significant air pollution. For pesticides, it was the most contaminated site found in Africa. Levels of PCBs were quite low, and PAHs were at the same level as at the other urban or rural sites. Their levels were highest in January and February. HCB was slightly elevated but the level of PeCB was an order of magnitude higher than any other site except for Egypt. DDTs (2584 ng filter⁻¹) and HCHs (2451 ng filter⁻¹) were measured at concentrations 2-3 orders of magnitude higher than most of the other sites (the maximum value was about four times higher than the median value). Levels of α -HCH were similar or higher than those of γ -HCH, and β -HCH reached only about 20% of their values. Most surprising were the levels of δ -HCH, which were 2-4 times higher than those of α -HCH or γ -HCH. It was also confirmed in the soil samples where α -, β - and γ -HCHs had similar concentrations and δ -HCH was about two times higher (Annex Table E30). *p,p'*-DDT and *p,p'*-DDE were found at similar levels in air, where *p,p'*-DDE prevailed most of the times. In the soil sample, *p,p'*-DDT was an order of magnitude higher than *p,p'*-DDE.

Industrial site is positioned in the heart of the industrial area. The main expected sources of POPs were industrial activities, open burning of used tires and vehicle exhausts. PCBs were the third highest found in this campaign, their levels being especially high in March and May. PCB 28 and 52 were generally most abundant but all the other indicator congeners were also found (especially high in May). PCB 153 and 138 were most abundant in soil. In addition, DDT and PAH contamination were high, an order of magnitude

higher than backgrounds for DDTs and up to 30 times higher than backgrounds for PAHs. Soil concentration of DDTs at this site as well as in Kitengela and Dandora sites were the highest in the survey. PAH concentrations were also the highest from all soils. HCHs and HCB levels did not differ from other sites.

Dandora sampling site is located close to the Nairobi municipal dump site. The main expected source of POPs was waste burning. Elevated levels of PCBs, HCHs and DDTs were found. More volatile PCBs as PCB 28 and 52 had levels several times higher than more chlorinated congeners. HCH concentrations were several times higher in dry season, whereas γ -HCH was more abundant than α -HCH which was often below detection limit. The levels of DDTs were also much higher in the warm months when p,p' -DDT dominated. The levels of p,p' -DDT in soil were slightly higher than of p,p' -DDE, and the concentration of o,p' -DDT surprisingly reached 60% of the p,p' -DDT concentration. The soil was quite heavily contaminated and probably acted as a source of the air pollution. For PAHs, the median air concentration was the fourth highest found in this survey while the soil concentration was the second highest. Additional information is given in Annex E Figures E 10 to E 22.

5.1.2.4.2. POPs levels in ambient air in Mali

Tombouctou is a background site in Mali located in a suburban area with minimal industrial activities (Annex E Figure E 19). The median PCB concentration was the lowest found in this survey, two orders of magnitude lower than in industrial sites in Senegal, Egypt or Kenya. PCB congeners were below detection limits in most of the samples with the exception of May samples in which most of the congeners were detected. PCB 28 and 52 were found more often. Levels were also lowest among all samples for HCHs and DDTs: both were often below detection limits, with detectable levels only from May to June. The background status was confirmed by the PAH concentrations being the lowest after Mount Kenya and two background sites in South Africa. Lowest PAH levels were measured between March and May. This also perfectly corresponds with low I-TEQ concentrations of PCDDs/Fs. Traces of dieldrin, heptachlor, mirex and chlordanes were detected, but endosulfan was found to have the highest concentration of all measured pesticides. It was an order of magnitude higher than endosulfan concentration measured at Mt. Kenya, but still more than an order of magnitude lower than the ones measured at most contaminated sites.

Bamako center is an urban sampling site with a waste dump and open fire incineration nearby. It was the most contaminated site in Mali. PCB levels were among the most contaminated, similar to industrial sites in Kenya, Sudan or Congo. Interestingly, higher chlorinated congeners (especially PCB 153) were found at higher concentrations than more volatile congeners. The levels were 50% higher in the samples collected in the last three months. HCH levels were also elevated. Similar to other industrial sites, γ -HCH was up to ten times more abundant than α -HCH. DDT concentrations were the fourth highest measured in the survey (after the obsolete pesticide storage site in Kenya, and the urban background sites in Senegal and Ethiopia) and p,p' -DDT was 2-4 times higher than p,p' -DDE. Levels of DDTs and HCHs were significantly higher in April and May. HCB and PeCB were detected in quantities similar to most of the other sites, while PAHs were almost an order of magnitude higher than those measured at the Tombouctou background site.

Bamako international airport is a rural site possibly affected by the air traffic and fuel combustion. PCB concentrations were at the urban level (half of the value of the town center but one order of magnitude higher than background), similar to HCH concentrations. γ -HCH was up to ten times more abundant than α -HCH. DDTs were still higher than those found in most countries and p,p' -DDE was higher than p,p' -DDT. Both DDTs and HCHs (and also PCBs) had much higher (up to an order of magnitude) concentrations in the last three campaigns (especially April-May). HCHs and HCB followed the uniform

distribution common in most countries, and PAHs were at the low level typical for sites not affected by massive combustion. Higher levels of PAHs (twice as high) were measured only in April.

Koutiala is a rural site in the agricultural (cotton growing) region possibly affected by pesticide usage or a cotton oil factory. PCB levels were quite low, although somewhat higher in the summer, and PCB 153 was the most abundant congener. HCH and especially DDT concentrations belonged to the higher levels found in this survey. γ -HCH was higher than α -HCH which was above detection limit only in the last months. The concentrations of DDTs were about three times higher in July than in the previous months, and levels of p,p' -DDE were 2-4 times higher than those of p,p' -DDT. HCB and PeCB levels were low but the PAH concentrations were the fourth highest (third maximum) in the survey. Levels of PAHs were 2-3 times higher in January and February.

Niono is an agricultural site possibly affected by pesticide usage. PCB concentrations were very low, similar to other background sites. The highest levels were measured in June. HCH and DDT levels were not very high either, and γ -HCH was most abundant among HCHs. p,p' -DDE concentration was between one half order and one order of magnitude higher than that of p,p' -DDT and was growing significantly from the beginning to the end of campaign. HCB and PeCB, as well as PAH concentrations were low. PAH concentrations in the first three months were several times lower than those in the last three months. Additional information is given in Annex E Figures E 23 to E35).

5.1.2.4.3. POPs levels in ambient air in Congo

Orstom de Brazzaville is an urban site. Possible sources of POPs could be stocks of obsolete pesticides, car emissions, sugar cane, cement and petroleum industries, as well as open municipal waste burning. PCB levels were quite high (higher in January and February than in subsequent months), similar to other big cities, and all indicator congeners were found in the samples. HCHs were elevated, α -, β - and γ -HCH were detected and γ -HCH was most abundant. p,p' -DDE concentration was somewhat higher than that of p,p' -DDT. Pesticides the levels were also higher in January and February. Dieldrin, mirex and endosulfan were detected in the air samples, all at higher concentrations in the second sampling period (April-July). Both dieldrin and endosulfan were found at similar or greater levels than HCHs and DDTs. PAH levels were similar to other urban sites and fluctuated around the same level for six months. The maximum I-TEQ level of PCDDs/Fs was among the highest determined in the region.

5.1.2.4.4. POPs levels in ambient air in Democratic Republic of Congo

Several sampling sites (8 together) were selected in the **University of Kinshasa**, in an urban area with some industrial facilities. Unfortunately, nothing can be said about the seasonal trends since 4 sites were sampled only in April while 4 other different sites were sampled in June. PCB levels were among the highest measured in this campaign; PCB 52 and 101 were the most abundant but all indicator congeners were detected. HCH concentration was similar to Congo (prevalent γ -HCH) but DDTs were almost three times higher (p,p' -DDT and p,p' -DDE were comparable). Median PAH levels were almost two times higher than in Congo with a 2-3 variability factor between the sites. Dioxins were not measured in Kinshasa.

5.1.2.4.5. POPs levels in ambient air in Egypt

This urban sampling site is located to the south of **Cairo** at Eltebin Institute, in the vicinity of various industries (cement, steel and iron). 40% of the total amount of industrial facilities in Egypt can be found in the greater Cairo. Greater Cairo is also surrounded by agricultural land and receives winds contaminated with pesticides coming from the south. This sampling site was the most contaminated with PCDDs/Fs in the whole African survey. Maximal I-TEQ concentration was an order of magnitude higher than the second most contaminated site (Dakar, Senegal) and almost three orders of magnitude higher than background sites. PAH levels were also high (second highest median concentration) and confirmed the severe influence of combustion on the air quality. PAH concentrations were higher between January and April (maximum) and decreased to 25% of the maximum value afterwards. PCDD/F concentration, however, did not decrease between the two sampling periods. The median PCB concentration was the second highest after Senegal with all congeners found with PCB 52 and 28 being most abundant. The HCH levels were also the highest apart from the obsolete pesticide storage site in Kenya. α -HCH was found at concentration levels 2-4 times higher than γ -HCH in most of the sampling periods and *p,p'*-DDT and *p,p'*-DDE were comparable. The sum of all DDTs was also high. The median levels of HCB and PeCB were at least an order of magnitude higher than at any other investigated site. The concentrations of aldrin (in the second from two 3-months sampling periods) and endosulfan were much higher compared to other pesticides. Other pesticides detected from the sites included dieldrin, endrin, heptachlor and mirex.

5.1.2.4.6. POPs levels in ambient air in Ethiopia

Asela is an urban background site located 175 km south-east of Addis Ababa city. It is a residential and public offices area, and least affected industrial or traffic emission sources. As the site is 2,372 m above sea level, possible sources of POPs could be atmospheric deposition and long-range transport. PCB levels were very low, at the level of the background sites. HCHs and DDTs were higher, and the detected median level of DDTs was the third highest from all investigated sites. While α -HCH was below detection limit in most samples, γ -HCH was always detected, and the levels were highest in June and January. DDT concentrations grew gradually from January to June and levels of *p,p'*-DDT were 2-4 times higher than those of *p,p'*-DDE. From the other pesticides, aldrin, dieldrin, heptachlor, mirex, chlordanes and endosulfans were detected. Level of endosulfans was the third highest after Ghana and Senegal, and was similar to DDT and higher than HCH concentration. The median concentration of PAHs in Ethiopia was the highest measured in this study; it was 30 times higher than at background sites and even higher than the level in Egypt. Lowest PAH levels were measured between February and March. Interestingly, PCDD/F levels were very low, with the highest I-TEQ concentration less than 1% of what was measured in Egypt.

5.1.2.4.7. POPs levels in ambient air in Ghana

Kwabanya is an urban background site some 20 km to the north- east of the Accra city centre at a research station that is distant from industrial and traffic emission sources. It is in a suburban residential area close to the Akwapim Mountains. Possible sources include agricultural activities where pesticides are applied, uncontrolled combustion activities, as well as motor vehicle emissions. PCBs were found at levels typical for urban sites. The concentrations of HCHs and DDTs were low, only 2-3 times higher than those at the background sites. The sums of HCHs and DDTs stayed the same throughout the sampling periods, and *p,p'*-DDE was higher than *p,p'*-DDT. Concentrations of HCB and PeCB were low, and only traces of aldrin, dieldrin, heptachlor and mirex were detected. While the concentrations of endosulfans were mainly below detection limit in the first sampling period, their levels were the highest in the second sampling period compared to all countries. They were also higher than the concentrations of all other pesticides.

PAH concentrations were only 2-3 times higher than those at the backgrounds, and the highest levels were detected in January. PCDD/F levels were, however, quite high with maximum I-TEQ value being the third highest in this survey after Egypt and Senegal.

East Legon is another urban background in a residential area 15 km to the north-east of the Accra city centre, close to the Accra international airport. It is not close to any industrial emission sources but may be affected by uncontrolled combustion activities (household/municipal wastes). It is about 25 km away from Tema, the industrial center of Ghana. PCB levels were slightly higher than those at the other site in Ghana. The same applies for DDTs and PAHs where the levels doubled. The concentrations of *p,p'*-DDE were higher than those of *p,p'*-DDT, and the sum of DDTs was highest in February and March. On the contrary, the levels of HCHs were highest in April and May.

5.1.2.4.8. POPs levels in ambient air in Mauritius

Reduit is a background site possibly affected by medical waste incineration or open waste burning. PCB and HCH as well as HCB and PeCB levels were low, similar to other background sites in Africa. The concentrations of DDT were 3-5 times higher than those typical for the background sites, and similar to the suburban sites in Kenya or Mali. Traces of dieldrin and mirex were also detected together with endosulfan which was higher than HCHs or DDTs. PAH concentrations in air were typical for rural sites not affected by heavy transport or industrial activities, but the concentrations in soil were among the highest in the region. This also corresponded with the low levels of PCDDs/Fs. The concentrations of PAHs measured in April and May were several times higher than in other months.

5.1.2.4.9. POPs levels in ambient air in Nigeria

Sheda is a site in the agricultural region potentially affected by bush burning. PCB levels were accordingly low except for the fourth month when they increased by ten times higher. HCHs and DDTs were very low as well, with γ -HCH dominating the HCH group and variable *p,p'*-DDE/*p,p'*-DDT ratio. Pesticide concentrations were highest in April. Traces of dieldrin, chlordanes and higher levels of endosulfans were also detected. PAH concentrations were also not high even though they were several times higher than those measured at background sites. Their levels were highest in January, February and April. On the contrary, PCDD/F levels were among the highest found in this study.

5.1.2.4.10. POPs levels in ambient air in Senegal

An urban industrial site in **Dakar** was selected as a sampling site in Senegal and it was one of the most contaminated sites. It provided the air samples with the highest median level of PCBs where concentrations of more chlorinated congeners (especially PCB 153) were significantly higher than those of more volatile PCB congeners. This pattern was also found in soil. Even though the soil was one of a few cases where PCBs were detected, it probably serves as a sink not a source of PCBs since levels are quite low. There must be another (possibly primary) source of PCB contamination of air. The levels of DDTs were also very high, second highest after the obsolete pesticide storage site in Kenya. *p,p'*-DDE and *p,p'*-DDT were found in the same order of concentrations. Soil was also contaminated, and *p,p'*-DDT dominated in soil. Endosulfans composed the group with the second highest air concentration measured in this campaign, while aldrin, dieldrin, heptachlor, isodrin, methoxychlor, mirex and chlordanes were detected at lower levels. The median concentration of PAHs was the third highest after Ethiopia and Egypt, the and

maximum I-TEQ of PCDDs/Fs was the second highest after Egypt. Highest levels of PAHs were measured in May, and the lowest in June. Soil concentrations of PAHs were also significantly high.

5.1.2.4.11. POPs levels in ambient air in South Africa

Three sampling sites were selected in South Africa: **Molopo Nature Reserve** is a background site with no industrial sources. The levels of PCBs, HCHs and DDTs were similar to those measured at the background sites in Kenya and Mali. For PCBs, the highest concentration was found in July (only the less chlorinated congeners were detected most of the time). The concentrations of HCHs (γ -HCH higher than α -HCH) were highest in January and February, and for DDTs (p,p' -DDT generally higher than p,p' -DDE) in January. Traces of aldrin and dieldrin and somewhat higher levels of endosulfans were found as well. PAH levels as well as PCDDs/Fs were the lowest after Mt. Kenya.

Barberspan is another non-industrial rural background with very similar results to Molopo Nature Reserve. The concentrations of all investigated POPs were almost identical to those measured at the previous site. The highest levels of HCHs and DDTs were found in January and February while the highest PCB levels were measured between April and July.

Vanderbijl Park is an industrial site affected by iron and steel manufacturing, a petrochemical plant, a powerplant and coal mining within a 20 km radius. PCB levels were 2-3 times higher than measured at the background sites in South Africa, DDTs were almost the same, but HCHs were one half order of magnitude higher with the highest levels between January and March. γ -HCH was up to one order of magnitude higher than α -HCH while p,p' -DDE/ p,p' -DDT ratio was variable. The median PAH level was high, similar to the industrial sites in Kenya and Mali. The soil levels of PAHs were among the highest in the region as well.

5.1.2.4.12. POPs levels in ambient air in Sudan

An urban industrial background was sampled in **Khartoum**. This site can reflect combustion processes in households and small industries, emissions from the asphalt mixing station, road traffic, and frequent solid waste burning. The concentration of PCBs was among the highest values, close to industrial sites in Kenya and Mali. As in the case of Senegal, PCBs were found also in the soil samples, but due to the low concentrations, soil is probably a sink not a source of pollution. Elevated levels were found for HCHs and DDTs. DDT contamination was also confirmed in soils; with p,p' -DDE being the most abundant. For all chlorinated compounds, the levels in the last three months of the campaign were about two times higher than those in the first three months. γ -HCH was up to one order of magnitude higher than α -HCH, while p,p' -DDE was 3-5 times higher than p,p' -DDT. From the group of other pesticides, aldrin, dieldrin, endrin, heptachlor, isodrin, mirex and chlordanes were found at low levels, and methoxychlor was about one order of magnitude higher. To the contrary, endosulfans were not detected. PAH concentrations were at levels typical for urban sites but the fourth highest I-TEQ concentration was found indicating significant PCDD/F air pollution.

5.1.2.4.13. POPs levels in ambient air in **Togo**

Kouma Konda is a sampling site in an agricultural area that is possibly affected by previous intensive use of DDT and cyclodien pesticides for coffee and cocoa production. This site may be probably impacted by the current use of endosulfan in cotton production. PCB levels were low which corresponds with the rural character of the site. The contrations of DDT were low, but the levels of HCH were the second highest apart from the pesticide dump site in Kenya. Levels of HCHs were much higher in the first three months of the year, especially in February. γ -HCH was responsible for this increase and the results suggested the fresh application of lindane. Similar concentrations were also measured for endosulfans, while aldrin, dieldrin and mirex were found in traces. PAH concentrations were quite low, and the levels of PCDDs/Fs were among the lowest in the region. PAH concentrations in January were several times higher than in June.

5.1.2.4.14. POPs levels in ambient air in **Tunisia**

Tunis city was sampled as an urban background site; some industrial facilities could be potential sources of contamination. The PCB concentrations corresponded to the urban character of the site, DDTs were low, and HCHs were elevated. Most particular is that extremely high concentration of HCHs in the air sample from the very first sampling period. While 9 μg of HCHs per filter was measured at Kitengela pesticide storage site in Kenya in January, 17 μg per filter were found in Tunis at the same time. In Kenya, this concentration gradually decreased to 2 μg per filter in following months but in Tunis such a high concentration was not confirmed during the next sampling periods. The very unusual distribution of HCH isomers in Kenya (the same amount of α - and γ -, but up to five times higher δ -HCH) was repeated in all samples. On the contrary, the January air sample from Tunis had about the same levels of γ - and δ -HCH but it was never confirmed in following months. From the group of other pesticides, aldrin, dieldrin, mirex and endosulfans were detected. Endosulfans had the highest median level from all investigated pesticides. PAHs were low in Tunis but PCDDs/Fs were among the higher in this survey (fifth highest I-TEQ).

5.1.2.4.15. POPs levels in ambient air in **Zambia**

The sampling site in **Lusaka** served as an urban background. It is located close to Zambia's largest interantional airport, far from the heavy industrial activities (these are some 18 km to the west from the airport). The levels of PCBs, HCHs, HCB and PeCB were low at this site, but DDT levels were higher than those found at most of the other sites. All chlorinated compounds had significantly higher concentrations in January and February than in the later months. More volatile PCBs and γ -HCH dominated, and p,p' -DDT was 2-3 times more abundant than p,p' -DDE. Dieldrin, chlordanes and endosulfans were also detected in the air samples. Both, PAHs and PCDDs/Fs were measured at low concentrations. PAH levels were highest in February and lowest in March.

5.1.2.5 Comparison of the results from the African screening study to the model network in the Czech Republic.

The Czech Republic is the only country in the world with a fully developed air monitoring network based on passive air sampling devices active since 2005. The network consists of 37 sites including industrial, urban, rural, urban background, rural background and mountain sites. In this section, the results from first six months of 2008 derived from this network were compared to the results from the screening campaign in the African continent.

Tables 5.8-5.14 below show all African sampling sites grouped according to the site category into six classes (industrial, urban, rural, urban background, rural background and mountain sites). On the right sites of tables (upper corner), the same statistics is performed on the full set of the sites in Czech Republic. It is noteworthy that since this survey was organized for the purpose of global monitoring, and the global monitoring plan focuses on the background sites, statistical analysis of the set of background sites from the Czech Republic is also provided (lower corner) of the tables.

a) Comparison of DDT levels

DDTs concentrations ranged over three orders of magnitude in the atmosphere of Africa. At many sites, it was also significantly higher than DDT concentrations measured in Central Europe. The maximum levels found at the pesticide dump site were more than 30 times higher than maximum levels measured in the pesticide factory in the Czech Republic. The median values at some industrial sites were higher than the Czech industrial maxima, for instance the sampling site in Senegal. Urban and rural sites were not so extreme but levels were still high at some urban backgrounds, especially Ethiopia or Sudan, or even rural backgrounds such as Mali 03.

When we exclude the sites marked grey (Table 5.8) from the selection of sites for background monitoring, the remaining urban, rural and mountain background sites show the same DDT levels as those in the Czech Republic with the exception of Ethiopia, Sudan and Zambia.

Table 5.8: Comparison of the statistical evaluation of DDT concentrations in Africa (26 sites, left) and Czech Republic (summary of 37 sites, right).

DDTs	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹		DDTs	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹
Egypt	10.6	70.1	38.3	38.9		industrial sites	2.4	249.9	51.2	20.9
Kenya 03	1969.8	8969.9	3979.4	2584.4		urban sites	0.6	49.3	13.2	9.4
Kenya 04	19.8	98.6	54.2	48.7		rural sites	0.6	324.9	19.4	7.2
Kenya 05	14.7	40.1	25.0	20.1		urban backgrounds	7.5	24.0	13.4	11.6
Mali 02	68.6	163.8	113.1	101.4		rural backgrounds	5.4	11.2	8.5	8.3
Senegal	92.7	796.9	410.9	359.2		mountain backgrounds	0.6	25.5	7.3	6.1
South Africa 03	1.5	6.5	3.5	2.5						
Congo	8.9	27.7	16.9	14.3						
DR Congo	19.5	85.6	44.7	36.5						
Mali 04	23.4	74.1	37.3	28.8		DDTs	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹
Mali 05	3.7	24.4	10.9	9.3		Praha, Líbuš	5.4	11.2	8.5	8.3
Nigeria	1.7	14.9	6.4	4.7		Košetice, EMEP station	7.5	12.6	9.4	8.7
Togo	2.8	6.5	4.6	4.5		Pláňavy, Štítná nad Vláří	8.4	24.0	17.4	18.0
Ethiopia	61.5	152.4	108.1	110.6		Bílý Kříž, Beskydy mountains	1.5	18.2	5.5	3.4
Ghana 01	4.5	6.1	5.2	5.1		Děčínský Sněžník, Krušné mountains	5.3	25.5	13.4	12.0
Ghana 02	7.9	20.6	12.1	10.5		Churaňov, Šumava mountains	0.6	4.3	2.6	2.5
Kenya 02	3.5	12.6	7.7	7.1		Jeseník, Jeseníky mountains	4.9	8.1	6.9	7.1
Sudan	45.2	111.9	75.3	68.8		Klet', Šumava mountains	0.6	5.4	2.9	2.7
Tunisia	1.5	5.7	3.4	3.4		Liberec, Ještěd	0.6	7.1	5.4	6.1
Zambia	13.2	77.8	36.5	23.3		Přímda, Šumava mountains	3.5	7.4	5.7	5.7
Mali 01	0.6	3.0	1.8	1.8		Rudolice, Krušné mountains	3.7	12.7	6.3	5.3
Mali 03	2.8	139.2	37.7	15.4		Rýchory, Krkonoše mountains	3.5	9.9	7.3	7.7
Mauritius	3.8	21.3	9.3	7.8		Sedlec, Mikulov	8.1	21.5	17.3	18.8
South Africa 01	1.1	3.1	1.8	1.5		Svatouch	6.6	18.5	10.4	8.9
South Africa 02	1.0	5.5	2.9	2.1		Šerlich, Orlické mountains	0.6	8.4	4.4	4.9
Kenya 01	1.3	2.4	1.9	2.0						

Sites are divided into industrial (pink), urban (orange), rural (bright green), urban background (yellow), rural background (light green), and mountains (blue).

b) Comparison of PCBs levels

PCBs at the industrial sites in Africa have similar levels as in Central Europe (Table 5.9). The maxima found in Africa were somewhat lower than those from Europe, but the median value in Senegal was, however, several times higher than European median levels. The sampling site in Kinshasa (Democratic Republic of Congo) should be considered – according to PCB level – to be industrial rather than urban. While rural sites and rural backgrounds in Africa had both maxima and median PCB levels lower than corresponding sites in Central Europe (with the exception of Mali 03), urban backgrounds in Africa were significantly higher in maximal and median levels for Sudan, Ghana or Tunisia.

Table 5.9: Comparison of the statistical evaluation of PCB concentrations in Africa (26 sites, left) and Czech Republic (summary of 37 sites, right).

PCBs	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹		PCBs	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹
Egypt	25.3	46.4	38.8	41.6		industrial sites	1.7	231.9	44.3	22.2
Kenya 03	3.0	5.8	4.8	5.0		urban sites	0.7	47.3	15.5	13.3
Kenya 04	11.7	71.3	40.9	36.0		rural sites	0.7	28.9	7.7	7.7
Kenya 05	22.2	34.7	26.0	24.7		urban backgrounds	4.3	11.5	6.8	5.9
Mali 02	14.9	26.1	20.0	19.4		rural backgrounds	5.6	13.4	9.1	8.6
Senegal	54.3	132.5	93.3	103.6		mountain backgrounds	0.7	15.3	5.5	5.1
South Africa 03	1.0	4.5	3.1	3.1						
Congo	6.8	16.2	10.3	8.6						
DR Congo	23.1	102.2	39.1	30.4						
Mali 04	2.0	5.0	3.7	3.9		PCBs	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹
Mali 05	0.9	2.8	1.4	1.2		Praha, Libuš	5.6	13.4	9.1	8.6
Nigeria	1.4	12.9	3.7	1.5		Košetice, EMEP station	4.3	6.2	4.9	4.6
Togo	0.7	5.3	2.4	2.3		Pláňavy, Štítná nad Vláří	5.7	11.5	8.8	8.4
Ethiopia	1.2	2.5	1.8	1.7		Bílý Kříž, Beskydy mountains	2.1	11.4	5.0	4.4
Ghana 01	8.2	12.6	10.1	9.7		Děčínský Sněžník, Krušné mountains	3.6	15.3	11.7	12.9
Ghana 02	6.9	20.3	12.8	11.4		Churáňov, Šumava mountains	0.7	7.8	4.6	5.1
Kenya 02	1.6	2.8	2.2	2.1		Jeseník, Jeseníky mountains	3.3	6.1	4.8	4.9
Sudan	13.8	39.2	23.6	20.5		Klep, Šumava mountains	0.7	5.0	3.0	2.6
Tunisia	8.1	19.1	11.7	10.2		Liberec, Ještěd	0.7	9.0	4.9	4.7
Zambia	1.5	7.9	3.5	2.5		Přimda, Šumava mountains	3.2	7.6	5.3	4.7
Mali 01	0.7	3.2	1.2	0.8		Rudolice, Krušné mountains	3.5	11.5	6.5	5.6
Mali 03	3.5	25.6	12.0	9.7		Rýchory, Krkonoše mountains	3.3	6.7	4.9	5.0
Mauritius	1.1	3.5	1.8	1.7		Sedlec, Mikulov	2.9	6.8	5.7	6.4
South Africa 01	0.8	6.1	1.8	1.2		Svratouch	4.5	8.6	6.2	6.1
South Africa 02	0.9	1.9	1.4	1.4		Šerlich, Orlické mountains	0.7	7.2	3.8	4.6
Kenya 01	0.7	2.4	1.4	1.3						

Sites are divided into industrial (pink), urban (orange), rural (bright green), urban background (yellow), rural background (light green), and mountains (blue).

Looking at the individual background sites it can be concluded that all rural sites, rural backgrounds and mountains are at levels similar or lower than in the Czech Republic and can be used for the purpose of the global monitoring. Sites marked grey were never meant for the background monitoring, but were added to the network to indicate the contamination gradient. The urban backgrounds, although higher in PCB levels, can also be included in the monitoring programme if needed. The industrial sites in Egypt and Senegal as well as the site in Kinshasa are not fit the background monitoring (marked red in Table 9) and should be replaced (unless the monitoring of impacted sites is intended).

Comparison of HCB levels

Atmospheric levels of HCB and PeCB were generally significantly lower in Africa than those found in Central Europe. None of the industrial sites was heavily polluted with these compounds. Although the median HCB concentration in Egypt was at the same level as the one detected for industrial sites in the Czech Republic, the maxima were almost two orders of magnitude lower. HCB levels at background sites of all categories in Africa were up to one order of magnitude lower (Table 5.10).

Table 5.10: Comparison of the statistical evaluation of HCB concentrations in Africa (26 sites, left) and Czech Republic (summary of 37 sites, right).

HCB	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹	HCB	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹
Egypt	9.0	23.4	17.8	20.9	industrial sites	1.3	1583.7	243.2	15.4
Kenya 03	3.7	6.0	5.2	5.4	urban sites	0.1	58.5	12.7	8.9
Kenya 04	3.6	4.6	4.2	4.2	rural sites	0.1	13.3	7.6	8.2
Kenya 05	4.5	12.4	7.9	7.9	urban backgrounds	6.5	17.6	11.6	11.2
Mali 02	1.4	4.7	2.6	2.6	rural backgrounds	6.1	10.2	8.4	8.4
Senegal	2.3	3.4	2.8	2.8	mountain backgrounds	0.1	24.3	9.2	8.7
South Africa 03	1.4	3.8	2.8	2.7					
Congo	1.0	2.5	1.7	1.8					
DRCongo	0.9	2.9	1.7	1.6					
Mali 04	1.3	2.8	2.0	1.9					
Mali 05	0.9	3.2	1.7	1.6	HCB	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹
Nigeria	1.2	2.2	1.8	1.8	Praha, Libuš	6.1	10.2	8.4	8.4
Togo	1.6	2.3	2.0	2.0	Košetice, EMEP station	7.4	11.5	10.4	11.0
Ethiopia	2.8	4.1	3.2	3.1	Pláňavy, Štítná nad Vláří	6.5	17.6	12.8	13.2
Ghana 01	1.7	2.6	2.0	1.9	Blýž Kříž, Beskydy mountains	4.3	13.8	8.2	8.2
Ghana 02	1.2	2.8	1.7	1.5	Děčínský Sněžník, Krušné mountains	7.0	24.3	15.1	13.2
Kenya 02	0.4	2.3	1.5	1.8	Churáňov, Šumava mountains	0.1	8.8	6.6	7.6
Sudan	1.8	7.3	3.4	2.8	Jeseník, Jeseníky mountains	7.5	12.9	9.7	9.8
Tunisia	0.8	11.6	3.3	1.8	Klet', Šumava mountains	0.1	8.6	5.8	6.8
Zambia	0.8	3.4	2.1	1.8	Liberec, Ještěd	0.1	8.7	6.8	8.3
Mali 01	2.0	4.0	2.8	2.7	Přimda, Šumava mountains	8.0	10.6	9.4	9.5
Mali 03	1.2	2.9	2.1	2.2	Rudolice, Krušné mountains	6.2	14.0	9.5	8.6
Mauritius	0.1	3.2	1.6	1.5	Rýchory, Krkonoše mountains	6.7	13.0	9.8	9.4
South Africa 01	0.3	1.3	1.0	1.1	Sedlec, Mikulov	6.9	10.3	9.1	9.4
South Africa 02	0.1	2.0	1.1	1.0	Svratouch	8.7	20.9	13.8	13.4
Kenya 01	1.6	6.0	3.2	2.5	Šerlich, Orlické mountains	0.1	10.8	6.4	8.7

Sites are divided into industrial (pink), urban (orange), rural (bright green), urban background (yellow), rural background (light green), and mountains (blue).

Comparison of PeCB levels

PeCB showed similar characteristics as HCB. Higher median and maximal values of PeCB were found in Egypt and Kenya but these were still more than an order of magnitude lower than maxima measured in Europe (Table 5.11).

The levels of pentachlorobenzene, a degradation product of HCB, closely followed the pattern exhibited by HCB. The concentrations measured in Egypt were one order of magnitude higher than all the other countries except for Kitengela dumpsite which had values almost as high. The concentrations of HCB and PeCB in soil were negligible.

Table 5.11: Comparison of the statistical evaluation of PeCB concentrations in Africa (26 sites, left) and Czech Republic (summary of 37 sites, right).

PeCB	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹	PeCB	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹
Egypt	8.7	33.0	20.7	22.5	industrial sites	0.4	1082.6	127.6	4.7
Kenya 03	6.6	13.8	11.0	11.4	urban sites	0.1	39.8	5.4	2.4
Kenya 04	1.5	3.2	2.2	2.1	rural sites	0.1	4.5	2.1	2.2
Kenya 05	2.6	13.0	6.9	6.0	urban backgrounds	0.9	4.2	2.4	2.2
Mali 02	0.3	3.3	1.3	0.9	rural backgrounds	0.9	2.9	2.1	2.2
Senegal	0.1	1.4	0.7	0.9	mountain backgrounds	0.1	4.8	2.2	2.1
South Africa 03	0.1	1.2	0.6	0.8					
Congo	0.3	1.7	0.9	0.9					
DR Congo	0.1	0.8	0.4	0.3					
Mali 04	0.1	1.7	0.8	0.6	PeCB	MIN	MAX	MEAN	MEDIAN
Mali 05	0.1	1.8	0.6	0.4		ng filter ⁻¹	ng filter ⁻¹	ng filter ⁻¹	ng filter ⁻¹
Nigeria	0.1	1.5	0.7	0.8	Praha, Libuš	0.9	2.9	2.1	2.2
Togo	0.3	1.9	1.1	1.2	Košetice, EMEP station	0.9	2.9	2.0	2.0
Ethiopia	0.1	1.5	0.9	1.1	Plánávy, Štítná nad Vláří	1.0	4.2	2.9	3.1
Ghana 01	0.3	1.5	0.8	0.7	Bílý Kříž, Beskydy mountains	1.1	3.3	2.4	2.8
Ghana 02	0.1	1.2	0.7	0.8	Děčínský Sněžník, Krušné mountains	1.5	4.8	2.4	1.9
Kenya 02	0.1	1.2	0.5	0.3	Churáňov, Šumava mountains	0.1	2.5	1.7	1.9
Sudan	1.0	2.4	1.6	1.5	Jeseník, Jeseníky mountains	1.3	3.8	2.3	2.0
Tunisia	0.1	37.4	6.9	1.0	Klet', Šumava mountains	0.1	2.3	1.5	1.8
Zambia	0.5	0.9	0.7	0.7	Liberec, Ještěd	0.1	2.7	1.9	2.1
Mali 01	0.1	1.5	0.6	0.5	Přimda, Šumava mountains	1.6	3.1	2.2	2.1
Mali 03	0.1	1.2	0.6	0.5	Rudolice, Krušné mountains	1.6	3.0	2.2	2.0
Mauritius	0.1	0.9	0.4	0.4	Rýchory, Krkonoše mountains	1.6	3.5	2.5	2.6
South Africa 01	0.1	0.9	0.4	0.2	Sedlec, Mikulov	1.4	2.9	2.0	1.9
South Africa 02	0.1	0.9	0.5	0.5	Svratouch	1.8	4.7	2.9	2.7
Kenya 01	0.4	1.0	0.6	0.5	Šerlich, Orlické mountains	0.1	3.4	1.9	2.3

Sites are divided into industrial (pink), urban (orange), rural (bright green), urban background (yellow), rural background (light green), and mountains (blue).

Comparison of HCHs levels

Extremely high levels of HCHs (median of 2451, maximum 9307 ng filter⁻¹) corresponding to median air concentrations between 10 and 20 ngm⁻³ were measured near the obsolete pesticide dump site in Kenya. At all the other sites, concentrations were quite uniform with the background sites in Zambia, South Africa, Mauritius or Mali being at the lower end (below 5 ng filter⁻¹) and Egypt, Togo and Tunisia at the higher end (Table 5.12).

The range between 3.5 and 47 ng per filter reflects an atmospheric concentration between 35 and 470 pgm⁻³. This corresponded with the GAPS results where the sum of α - and γ -HCH ranged from trace levels to 184 pgm⁻³.

Very high HCH concentrations were also measured in the soil samples from the Kitengela dump site in Kenya, while the soil concentrations at other sites were negligible (around 1 ngg⁻¹). Isomer specific analysis showed that δ -HCH was most abundant isomer in soil, followed by γ -, β - and α -HCHs. The same unusual pattern was also reflected in ambient air where concentrations of δ -HCH were up to 5 times higher than the concentrations of any other isomer.

Table 5.12: Comparison of the statistical evaluation of HCH concentrations in Africa (26 sites, left) and Czech Republic (summary of 37 sites, right).

HCHs	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹		HCHs	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹
Egypt	34.1	101.8	60.3	47.1		industrial sites	1.4	26982.4	1182.7	13.9
Kenya 03	1 939.1	9 307.5	4 517.0	2 451.3		urban sites	0.4	619.2	29.4	9.1
Kenya 04	1.7	18.8	9.1	8.3		rural sites	0.4	18.7	7.2	6.9
Kenya 05	1.5	23.6	14.0	13.5		urban backgrounds	1.5	22.5	8.8	6.4
Mali 02	6.9	45.1	22.3	17.8		rural backgrounds	5.2	15.7	9.9	9.9
Senegal	9.9	29.1	20.1	21.2		mountain backgrounds	0.4	22.3	8.3	8.0
South Africa 03	8.7	43.7	23.4	21.4						
Congo	10.2	14.8	12.9	13.4						
DR Congo	6.8	16.0	12.6	13.8						
Mali 04	3.4	17.7	10.4	10.2		HCHs	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹
Mali 05	3.0	7.2	4.5	4.3		Praha, Libuš	5.2	15.7	9.9	9.9
Nigeria	3.6	10.1	6.9	7.5		Košetice, EMEP station	2.6	22.5	8.4	4.9
Togo	19.7	147.4	60.8	43.3		Pláňavy, Štítná nad Vláří	1.5	17.4	9.3	8.8
Ethiopia	1.2	38.5	16.5	13.9		Bílý Kříž, Beskydy mountains	1.3	11.7	5.6	5.4
Ghana 01	6.3	9.2	8.1	8.4		Děčinský Sněžník, Krušné mountains	5.4	21.5	10.5	8.1
Ghana 02	3.3	17.7	9.1	7.9		Churaňov, Šumava mountains	0.4	19.0	8.7	8.5
Kenya 02	4.6	30.9	10.5	7.0		Jeseník, Jeseníky mountains	1.2	11.3	7.6	9.8
Sudan	7.5	18.0	12.4	12.0		Klet', Šumava mountains	0.4	22.3	11.0	10.9
Tunisia	16.8	17 014.4	2 860.4	34.0		Liberec, Ještěd	0.4	19.5	9.8	9.7
Zambia	2.0	9.3	4.2	3.5		Přímda, Šumava mountains	6.7	14.7	11.2	11.1
Mali 01	1.9	7.4	4.0	3.5		Rudolice, Krušné mountains	3.7	12.4	8.1	8.6
Mali 03	4.9	29.4	14.1	9.1		Rýchory, Krkonoše mountains	2.8	11.7	5.6	4.8
Mauritius	2.3	15.6	6.8	4.9		Sedlec, Mikulov	7.1	20.7	11.9	10.6
South Africa 01	2.0	8.9	4.7	4.0		Svatouch	1.5	10.8	6.4	6.9
South Africa 02	2.3	12.3	7.1	4.9		Šerlich, Orlické mountains	0.4	8.0	3.3	3.0
Kenya 01	4.9	19.7	9.9	7.5						

Sites are divided into industrial (pink), urban (orange), rural (bright green), urban background (yellow), rural background (light green), and mountains (blue).

The maximum HCH levels at the pesticide dumping site in Kenya as the most HCH contaminated site in Africa reached similar maximum values measured in the pesticide factory in the Czech Republic. All the other sites were several orders of magnitude lower. Rural and mountain backgrounds showed HCH concentrations similar to the backgrounds in Central Europe and can be used for the purpose of background monitoring. There is a problem in Tunisia where HCH levels were generally high but reached a value three orders of magnitude higher than usual in one of the sampling periods. This indicates a recent application of HCH in the country or the source region. This is also suggested by one of the highest minimal values from all sampling sites. A similar problem, although without the extreme level, was also observed at the rural agricultural site in Togo. Though these sites probably reflect the current use of pesticides, this generally does not disqualify them from being good candidates for monitoring provided that the long-term trends of pesticides in impacted areas are also investigated.

Comparison of PAHs levels

The concentrations of PAHs were also determined in samples analysed for POPs. The concentrations obtained are shown in Annex E Tables E32 to E60 and Figures E7 to E8). The highest levels of PAHs were measured at the urban background site in Ethiopia (15.5 µg filter⁻¹ corresponding to 80-150 ngm⁻³), industrial sites in Egypt (11 µg filter⁻¹), Senegal (9 µg filter⁻¹), and the municipal dumpsite in Kenya and a cotton growing region in Mali. Air levels were also higher at the urban sites in Congo and DR Congo, Ghana, South Africa and Sudan. Phenanthrene was always the most abundant polyaromatic compound. Very clean samples came from Mountain Kenya, Tombouctou in Mali, and the two background sites in South Africa.

It has to be noted that PAH compounds in ambient air partition between the gas and particle phases. As the passive air samplers are designed to sample the gas phase only (although a finest particle fraction cannot be prevented from entering the samplers), particle fraction in the atmosphere tends to be underestimated. It does not represent a significant error in terms of concentrations since the amount of particle-associated PAHs is usually an order of magnitude lower than the one of gas phase-associated PAHs. It can, however, cause a serious underestimation of the risks since the particle-bound PAHs are significantly more toxic.

None of the soils exceeded the concentration of 220 ng g^{-1} , and levels were highest in Kenya, Senegal and Mauritius.

The median PAH levels at Mt. Kenya, Tombouctou and sampling sites in South Africa were very low, with concentration of half an order of magnitude lower than medians found in Europe. The concentrations at other rural and most of the urban sites were more comparable with corresponding site categories in Czech Republic. The industrial sites are the only category where the median values of PAHs in Africa were generally higher than those in the Czech Republic even though their maxima were lower.

Apart from the sites marked grey (selected for other purposes), all the other sites can be used for the purpose of background monitoring. The only exception is Ethiopia, where the mean and median values were the highest in the campaign (Table 5.13).

Table 5.13: Comparison of the statistical evaluation of PAH concentrations in Africa (26 sites, left) and Czech Republic (summary of 37 sites, right).

16 PAHs	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹		16 PAHs	MIN ng filter ⁻¹	MAX ng filter ⁻¹	MEAN ng filter ⁻¹	MEDIAN ng filter ⁻¹
Egypt	4 810	22 954	11 636	11 062		industrial sites	1 747	29 973	8 418	5 743
Kenya 03	818	1 316	1 117	1 182		urban sites	11	27 219	5 920	3 824
Kenya 04	6 211	8 445	7 147	6 807		rural sites	11	60 412	7 544	4 788
Kenya 05	6 742	9 676	8 147	8 110		urban backgrounds	283	16 181	4 666	2 818
Mali 02	3 401	6 312	5 040	5 278		rural backgrounds	1 126	14 561	5 286	3 328
Senegal	5 672	13 289	9 279	9 152		mountain backgrounds	11	19 841	3 740	2 629
South Africa 03	3 518	7 799	5 434	5 218						
Congo	2 328	4 745	3 390	3 336						
DRCongo	4 053	13 151	6 423	5 669						
Mali 04	5 833	16 278	9 255	6 776		16 PAHs	MIN	MAX	MEAN	MEDIAN
Mali 05	581	3 460	1 890	1 594			ng filter ⁻¹	ng filter ⁻¹	ng filter ⁻¹	ng filter ⁻¹
Nigeria	1 408	6 025	3 669	3 549		Praha, Libuš	1 126	14 561	5 286	3 328
Togo	993	3 977	2 310	2 203		Košetice, EMEP station	283	9 226	3 240	1 932
Ethiopia	9 731	17 915	14 547	15 449		Pláňavy, Štítná nad Vláří	1 328	16 181	6 092	3 402
Ghana 01	1 652	2 786	1 951	1 749		Bílý Kříž, Beskydy mountains	507	6 182	3 210	3 066
Ghana 02	2 965	4 158	3 383	3 341		Děčínský Sněžník, Krušné	1 073	19 841	9 134	7 121
Kenya 02	1 566	2 312	1 942	2 005		Churáňov, Šumava mountains	11	2 514	1 292	1 179
Sudan	3 174	5 269	4 231	4 332		Jeseník, Jeseníky mountains	841	11 752	4 932	3 650
Tunisia	1 087	2 362	1 607	1 641		Klet', Šumava mountains	11	16 358	5 370	3 983
Zambia	834	2 182	1 618	1 583		Liberec, Ještěd	11	3 648	1 439	1 270
Mali 01	362	905	688	711		Přímda, Šumava mountains	588	5 620	3 044	2 903
Mali 03	1 102	2 793	1 726	1 623		Rudolice, Krušné mountains	451	8 189	3 799	3 292
Mauritius	1 792	5 434	3 127	2 529		Rýchory, Krkonoše mountains	834	3 228	1 866	1 568
South Africa 01	303	640	423	413		Sedlec, Mikulov	1 324	10 110	4 408	3 719
South Africa 02	233	564	385	402		Svatouch	1 255	11 403	4 866	4 288
Kenya 01	145	212	185	191		Šerlich, Orlické mountains	11	4 014	1 517	1 341

Sites are divided into industrial (pink), urban (orange), rural (bright green), urban background (yellow), rural background (light green), and mountains (blue).

5.2. CONCENTRATIONS OF POPs IN HUMAN MILK

Very limited information on the contamination of human milk by POPs is available in Africa. The main sets of data were obtained from WHO human milk survey campaigns, which involved some countries from the region. Egypt participated in the 3rd round in 2003, and Sudan in the 4th round in 2005. Due to the existing data gaps in the region, UNEP/WHO milk survey project was developed in which 14 African countries participated to provide additional human milk data.

5.2.1. Data from the 3rd and 4th Rounds of the WHO milk survey

As the 3rd and 4th Rounds of the WHO milk survey involved very few countries in the region, the data collected from Egypt during the 3rd round (Table 5.68 in Annexes), and from Sudan during the 4th round (Table 5.54 to 5.56 in Annexes) are mentioned in this report for record purpose. However, such data are not at all adequate in providing a baseline of POPs levels in human milk in the region upon which future evaluations can be done.

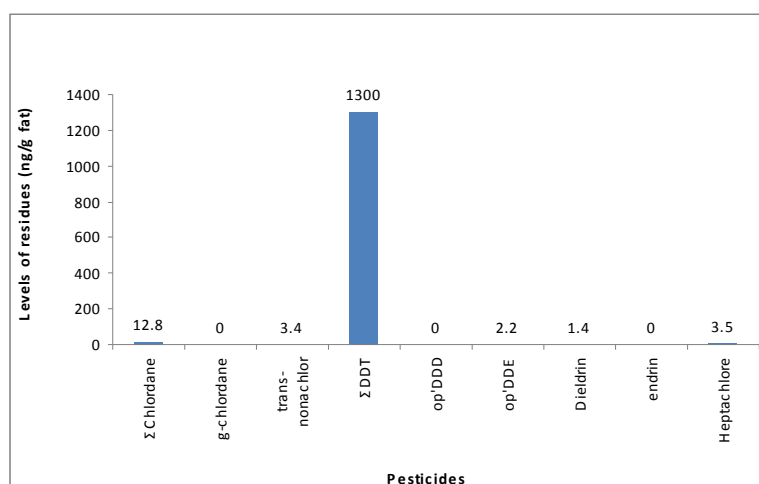
5.2.1.1. Results from the 3rd Round of WHO milk survey (Egypt)

Analysis of pooled human milk sample submitted in the 3rd round of WHO human milk survey only covered PCDD/F and PCBs. WHO-PCDD/F-TEQ of 22.33 pg/g of fat and WHO-PCB-TEQ of 5.48 pg/g of fat were reported (Annex E Table E 63).

5.2.1.2. Results from the 4th Round of WHO milk survey (Sudan)

5.2.1.2.1. Levels of basic POPs in human milk from Sudan

Among the POP pesticides, DDT and its metabolites were the most dominant in human milk samples collected from Sudan. Other pesticides detected included dieldrin, heptachlor, Hexachlorobenzene and chlordane. Aldrin, Endrin, Toxaphene and mirex were below detection limit. The results of the pesticide residues are illustrated below (Figure 5.11), and summarized in Annex E Table E 64.



ΣDDT = Sum of o,p'-DDT, p,p'-DDT, p,p'-DDE, and p,p'-DDD

Figure 5.11: POP pesticides in human milk from Sudan

5.2.1.2.2 PCBs levels in human milk from Sudan.

All indicator PCBs (PCB 28, PCB 52, PCB 101, PCB118, PCB 138, PCB 153, PCB 180) screened in the pooled milk sample were of detectable concentrations. The level of PCB 153 was the highest followed by PCB 138 and PCB 180 (Figure 5.12). Several other mono-ortho and non-ortho PCBs were also detected (Annex E Table E 65).

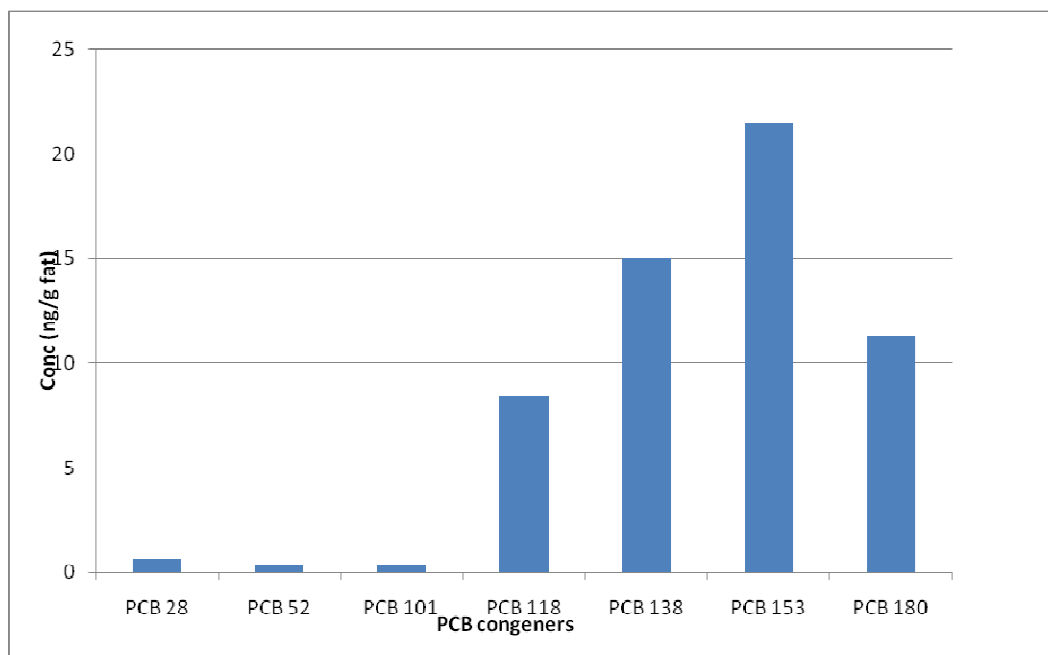


Figure 5.12: Concentrations of PCBs in human milk from Sudan

5.2.1.2.3 Dioxins and furans levels in human from Sudan.

The concentrations of dioxins and furans varied from one congener to the other in the pooled milk sample. Figure 5.13 below illustrates the detected levels. The concentration of OCDD was the highest of all the analysed compounds, whereas 2,3,4,7,8-PeCDF was the highest among the PCDFs. WHO-PCDD/F-TEQ of 6.2 was reported (Annex E Table E 66).

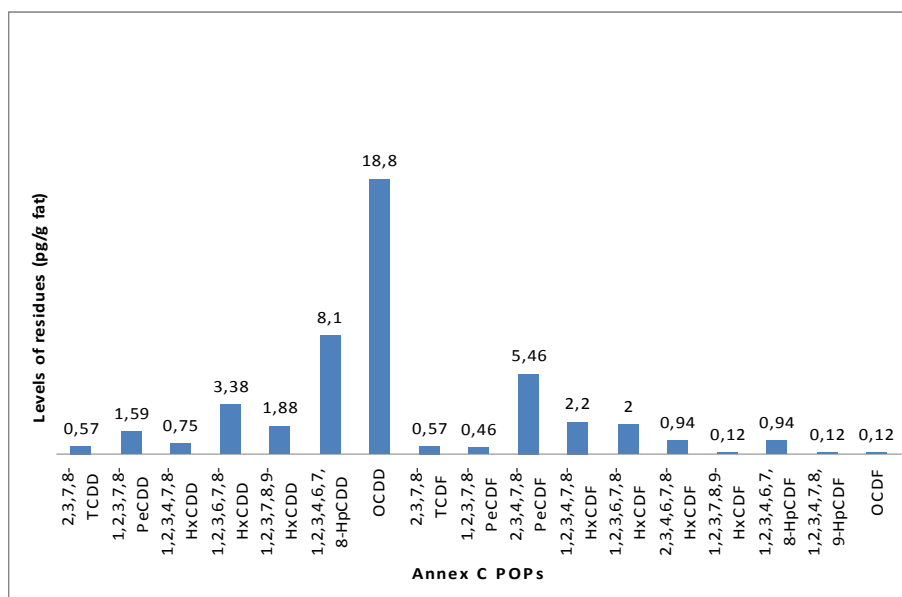


Figure 5.13: Dioxins and furans concentrations in human milk from Sudan

5.2.2. Data from the UNEP-WHO milk survey

Thirteen countries in the region showed interest in submitting human milk samples for the UNEP-WHO human milk survey under the 4th round that was coordinated by UNEP Secretariat of the Stockholm Convention. The countries included DR Congo, Congo Republic, Ivory Coast, Djibouti, Ghana, Guinea Conakry, Mali, Kenya, Mauritius, Niger, Nigeria, Senegal and Uganda. The data was meant to supplement the existing data from Egypt and Sudan in order to give a more comprehensive regional picture of the POPs levels in human milk. This data was not yet ready at the time of compiling this report.

5.2.3. Data on core media from other national activities

Although, there was no well established program for monitoring POPs in human tissues (milk and blood) in the region, a literature review revealed the existence of research data in some countries. However, it should be noted that the methodologies were not consistent with the recommended WHO method which is the international standard. Thus, the data from these studies/research activities are not suitable for comparisons and inferences for the region.

5.2.3.1. Human milk data from South Africa

DDT and its metabolites (DDE and DDD) were determined in 152 human milk samples from three towns in South Africa (Bouwman et al., 2006). The DDE recorded the highest concentrations in both the whole milk and milk fat, with concentrations ranging from 57.3 ng/g and 1716.6 ng/g respectively, followed by DDT with 34.3 ng/g and 1164.9 ng/g. Metabolite DDD recorded the lowest concentrations in both matrices (Annex E Tables E 68 to E 69)

5.2.3.2. Human milk data from Ghana

A referred publication on human milk in Ghana (Ntow, 2001) reported the presence of DDE and HCB at the concentrations of 490 ng/g and 40 ng/g respectively (Annex E Tables E 70 to E 73).

5.2.3.3. POPs Levels in human blood

Data on POPs levels in human blood was extracted from published research findings from Ghana. The studies reported the presence of DDT, DDE, dieldrin, and HCB (Annex Tables E 70 and E 71) (Ntow, 2001 and Ntow et al., 2008). Figure 5.14 below illustrates the levels of pesticides detected in Human blood Ghana.

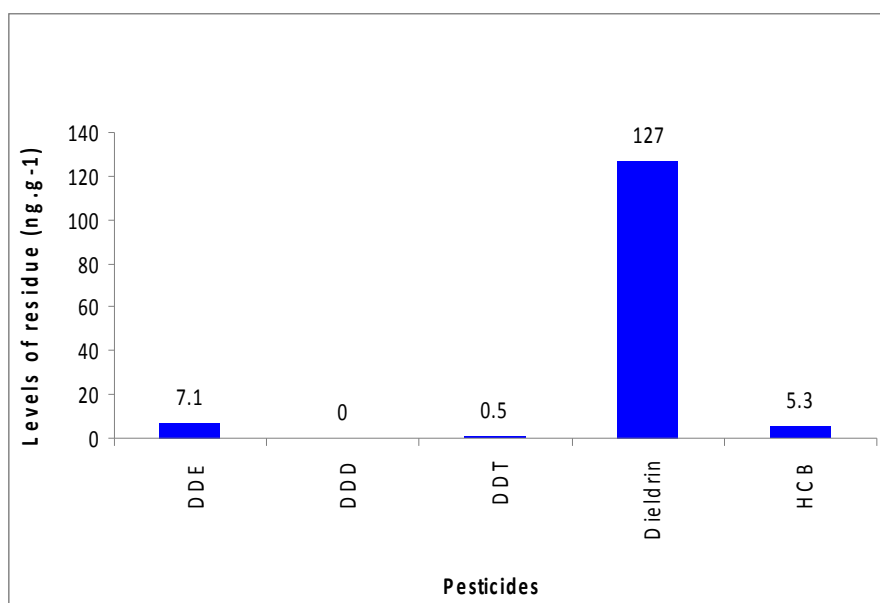


Figure 5.14: POP pesticides in human blood from Ghana (2008)

5.3 CONCENTRATIONS OF POPs IN OTHER MEDIA

Most of the available POPs monitoring data from countries within the Africa region were retrieved from published scientific papers from national research activities dealing with other media (crops, fish, meat, soil, sediments and water).

5.3.1 POPs pesticide residues in soil

Comparable data of POPs residues in soils from the region was obtained from the data obtained from soil samples submitted during MONET Africa pilot project. However, the data was from samples submitted once in March 2008, and not adequate for discussion of temporal trends, sources and sinks, and transport. The results are illustrated in the figures below, and summarised in Annex E Tables E30 and E31.

5.3.1.1 DDT levels in soil

DDT levels in soil varied from one country to the other. The highest concentration was measured in soil from Kitengela absolute pesticide site, where $175 \mu\text{g g}^{-1}$ of DDTs was found. *p,p'*-DDT was responsible for 80% of the total DDTs and even *o,p'*-DDT was two times more abundant than *p,p'*-DDE at this site. Around $1 \mu\text{g g}^{-1}$ of DDTs was found also at two other sites in Kenya – industrial site and municipal waste dumpsite. At these sites, the concentration levels of *p,p'*-DDT and *p,p'*-DDE were similar. Senegal and Sudan soil had some 100 ng g^{-1} of DDTs and all remaining soils stayed only in the range of nanograms. *p,p'*-DDE was prevalent in Sudan while *p,p'*-DDT was more abundant in Senegal (Figure 5.15). The actual concentrations of DDT in soils are given in Annex E Tables E30 and E31

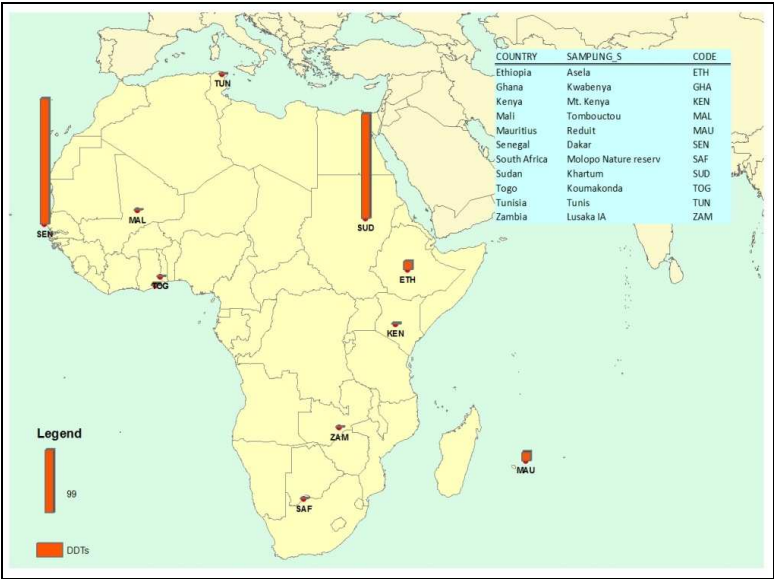


Figure 5.15: DDT levels (sum of *o,p'*- and *p,p'*-DDT, DDE, DDD) in soil (ng g^{-1}) in Africa, 2008

5.3.1.1.2 HCB levels in soil

Figure 5.16 below shows the levels of HCB in soils from the region. **The highest concentration** was detected in soil from Senegal.

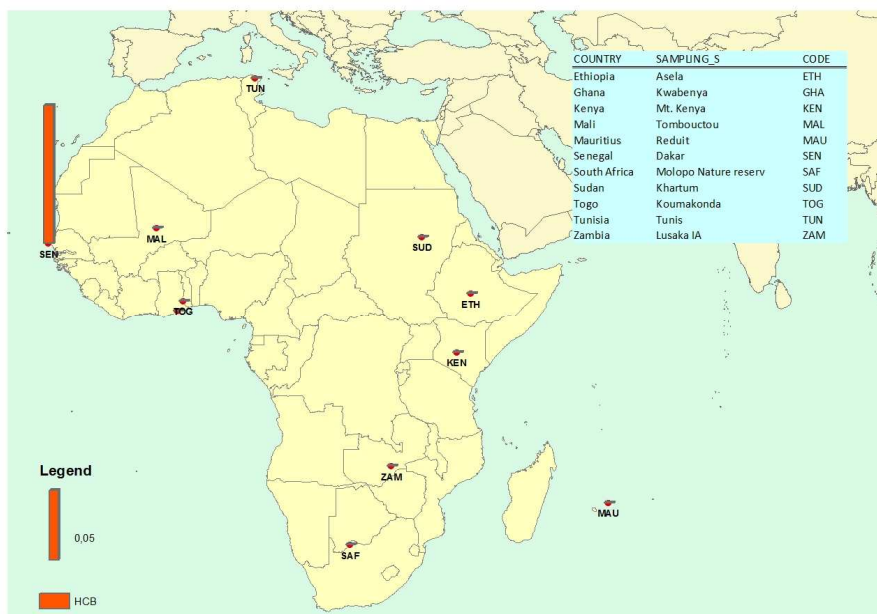


Figure 5.16: HCB levels in soil (ng g^{-1}) in Africa, 2008

Figure 5.17 below shows the levels of PeCB detected in soils from fifteen African countries. In general, the levels of this compound in soils were quite low compared to the parent compound which is HCB.

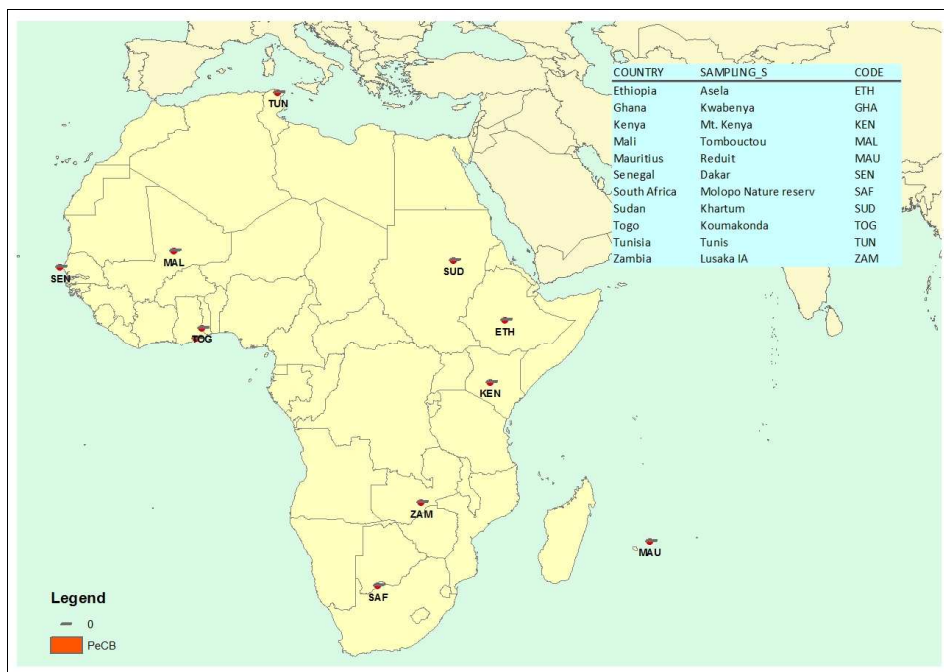


Figure 5.17: PeCB levels in soil (ng g^{-1}) in Africa, 2008

5.3.1.2 PCB levels in soils

Figure 5.18 below shows the sum PCB levels detected in soils from the region. The highest PCB concentrations were found in Sudan, followed by Senegal and Tunisia. They all were, however, very low (below 16 ng g^{-1}). Additional information of PCB residues in soils is given in Annex E Tables E30 and E31.

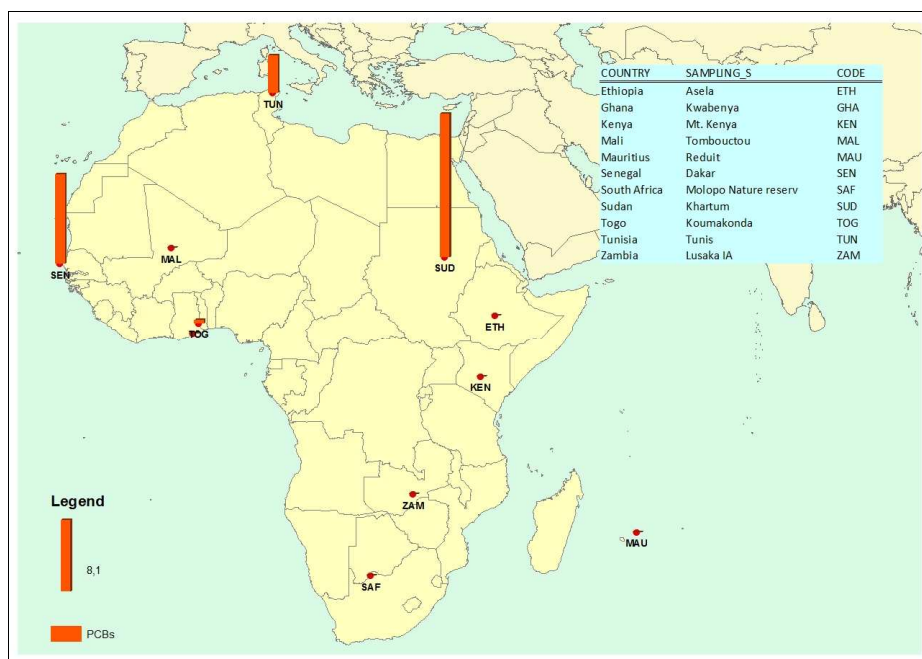


Figure 5.18: Sum PCB levels (7 indicator congeners) in soil (ng g^{-1}) in Africa, 2008

5.3.2. POPs levels in sediments

POPs pesticides were the main compounds reported by the research institutions in the region, whereas, DDTs, aldrin, dieldrin, heptachlor, endrin and mirex were the most reported pesticides in sediments.

5.3.2.1. Data from Ghana

Research findings by Ntow (2001) revealed presence of DDE, heptachlor and HCB in sediment from Ghana, with varying concentrations of 0.46 ng/g , 0.63 ng/g and 0.9 ng/g , respectively (Annex Table E71). Later studies reported presence of aldrin, dieldrin, DDT and its metabolites (Figure 5.19 and annex E Table E72).

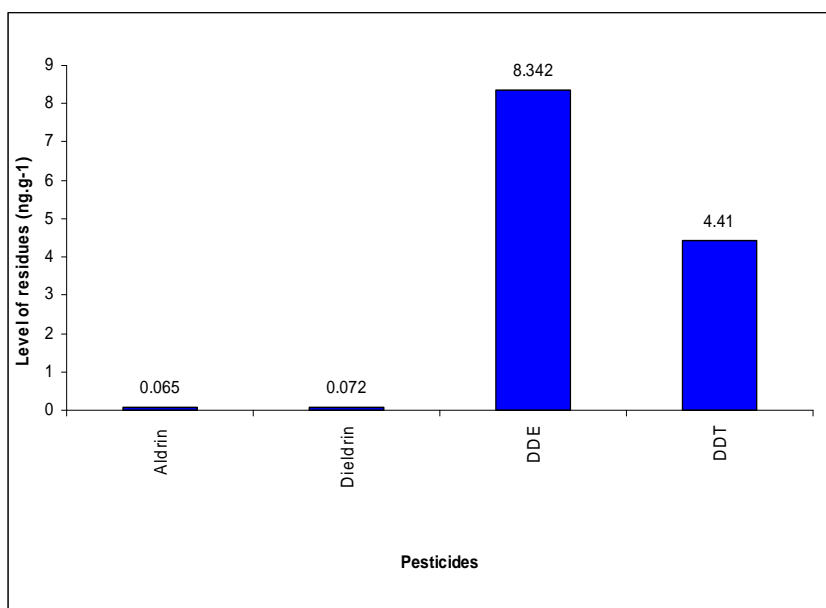


Figure 5.19: POPs residues in sediments from Ghana (Ntow et al., 2008)

5.3.2.2. Data from South Africa

Various POP pesticides have been reported in sediments from South Africa, with the concentration of HCB being the highest (Figure 5.20 and Annex E Table E68).

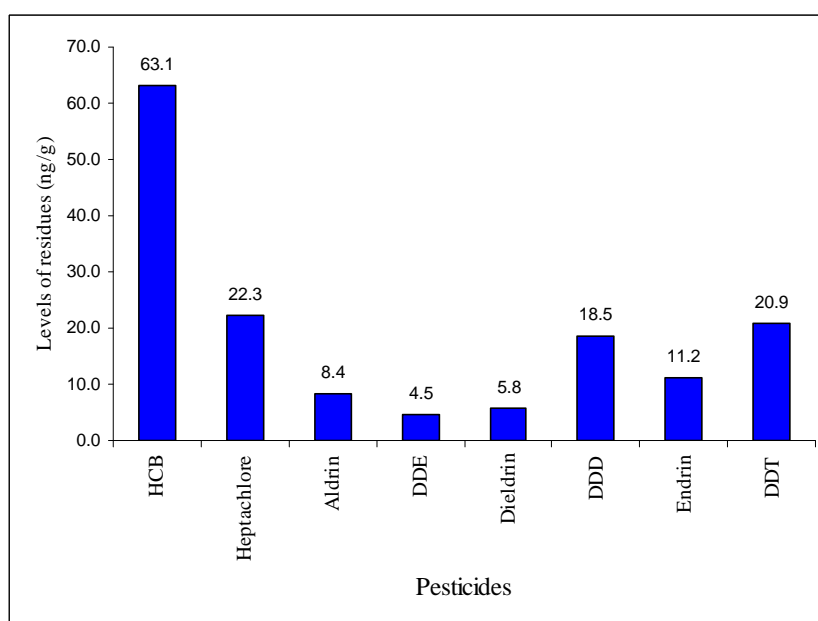


Figure 5.20: POP pesticide residues in sediments from South Africa (2003)

5.3.2.3. Data from Senegal

Seven POP pesticides (Aldrin, Dieldrin, Endrin, DDT, CHB, Heptachlor and Mirex) have been reported in soil from Senegal as shown in Figure 5.21 below, and Annex E Table E 73 (Manirakiza et al., 2003).

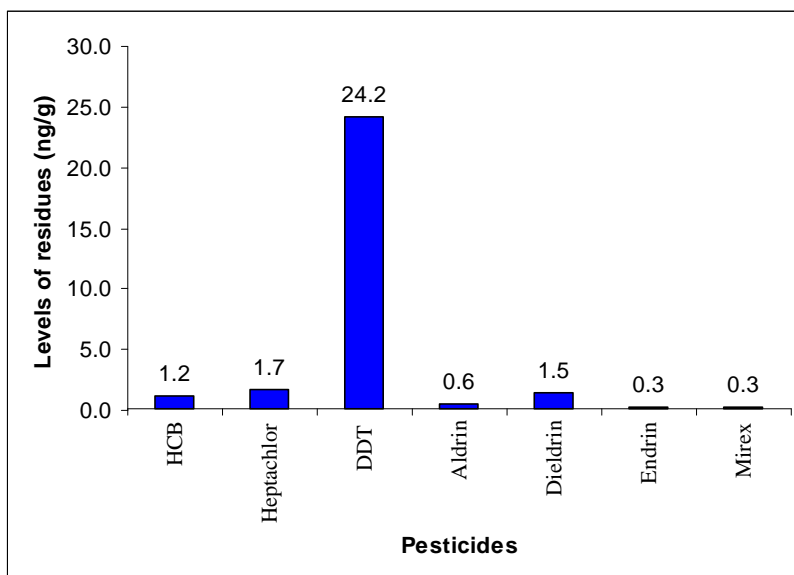


Figure 5.21: POPs in soil from Senegal in 2003

5.3.2.4. Data from Mali

Research findings from Mali revealed that the concentrations of pesticide residues in soil varied from one locality to the other (Annex E Table E74). The concentration of DDE was the highest detected compared DDT, whereas dieldrin and DDD were below detection limit. Later study by Dem et al. (2007) noted that although the reported pesticide residues in soil and water are generally low, more studies are necessary to assess the levels in water, soils and living organisms from other parts of the country.

5.3.3. POPs levels in water

5.3.2.1. Data from Ghana

POP pesticides are the main compounds reported in water samples by researchers in the region. A study by Ntow et al. (2008) reported DDT and DDE, at levels of 0.012 ng/l and 0.061 ng/l in water samples from Ghana, whereas the concentrations of aldrin and dieldrin were below detection limit (Annex E Table E72).

5.3.2.2 Data from South Africa

In a study in South Africa, aldrin, dieldrin, DDT and its metabolites HCB and heptachlor in water, with concentrations ranging from 21.1 to 209.7ng/l (Figure 5.22 and Annex E Table E 68) (Awofolu and Fatoki, 2003).

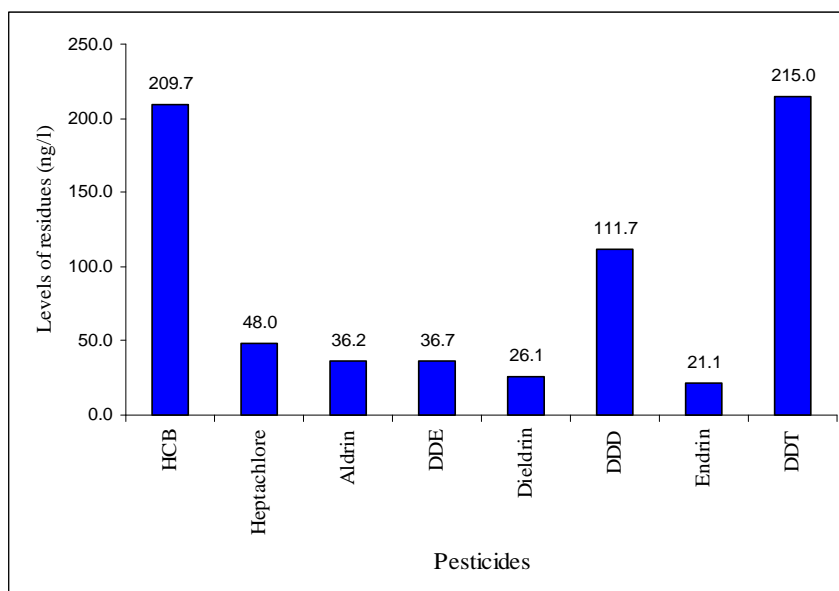


Figure 5.22: POPs in water from South Africa (2003)

5.3.2.3. Data from Senegal

In a research conducted in Senegal to determine pesticide residues in water, seven pesticides namely aldrin, dieldrin, endrin, DDT, HCB, heptachlor and mirex were detected at levels ranging from 0.1 to 63.9ng/l as shown in Figure 5.23, and Annex E Table E 73 (Manirakiza et al., 2003).

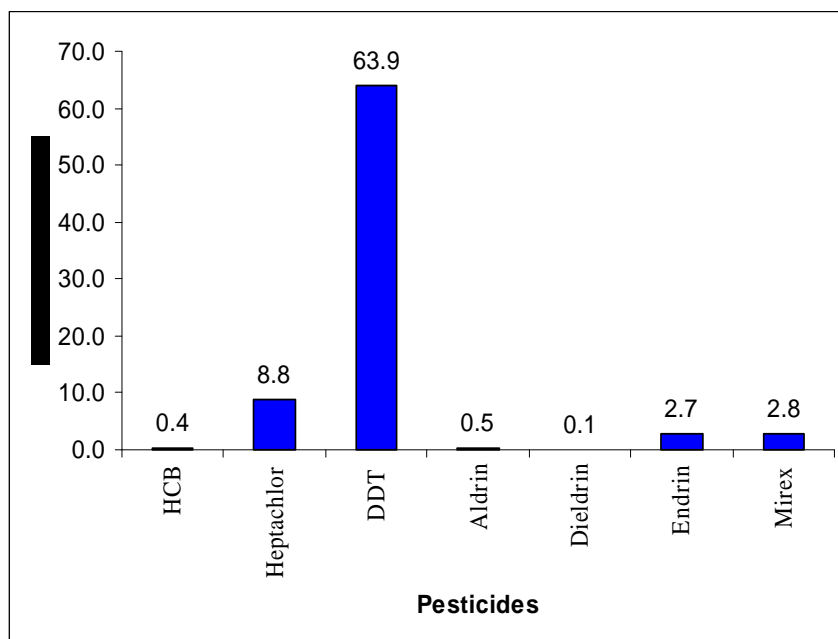


Figure 5.23: POPs in water from Senegal in 2003

5.3.4. POPs levels in meat

A study by Darko and Acquah, (2007) reported presence of aldrin, dieldrin, DDT and its metabolites in meat (fat and lean) samples from Buoho, Ghana. The concentrations ranged between below detection limit and 24.4 ng/g. The findings are summarised in Figure 5.24 below, and Annex E Table E 71).

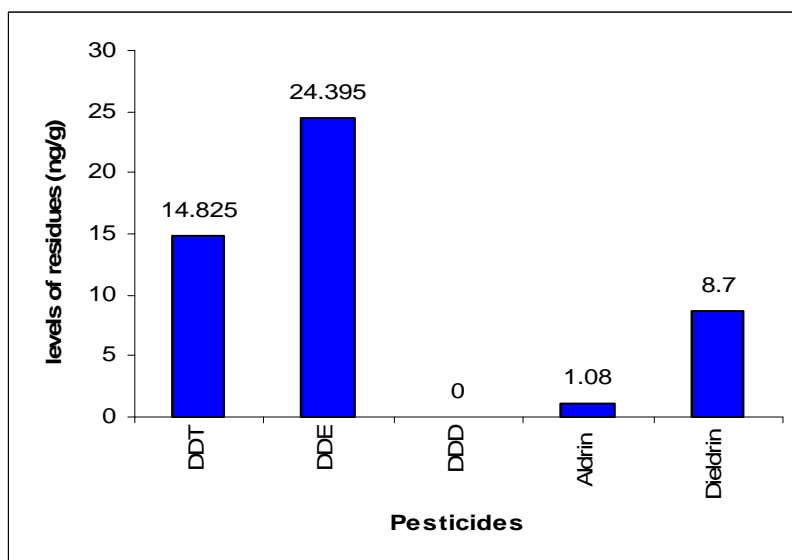


Figure 5.24: POPs in beef fat and lean from Ghana (2006).

5.3.4. POPs levels in fish

5.3.4.1. Data from Burundi

In Burundi, the POP pesticides such as adrin, dieldrin, eldrin, DDT and its metabolites, HCB and heptachlor were detected in some fish species with residue levels ranging from 2.3 to 197.6 ng/g as shown in Figure 5.25 and Annex E Table E 75.

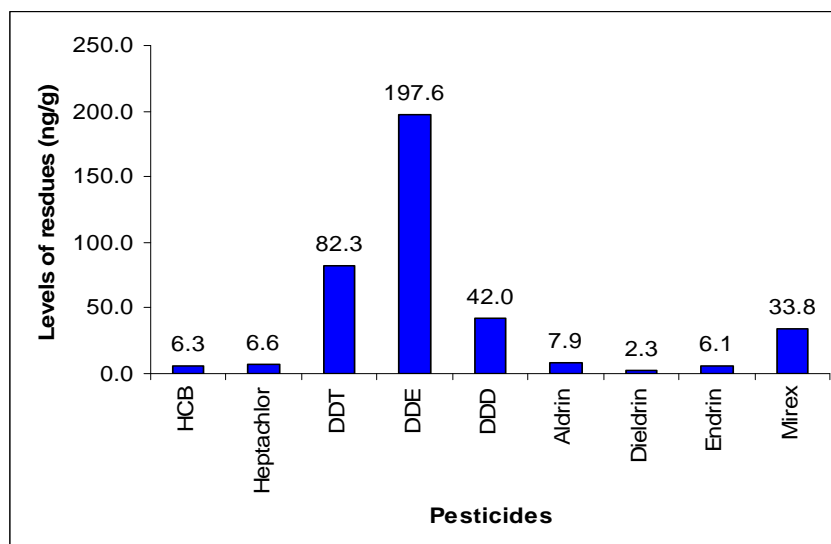


Figure 5.25: POPs levels in fish from Burundi (1999)

5.3.4.2. Data from Ghana

A study by Ntow et al. (2008) reported aldrin, dieldrin, DDT and DDE in fish samples from Ghana. The concentration of DDE was the highest compared to other pesticides detected (Figure 5.26 and Annex E Table E 72).

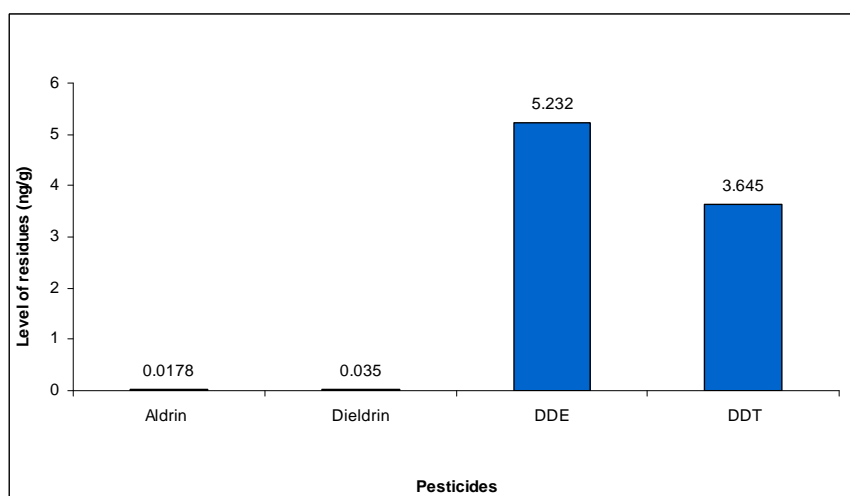


Figure 5.26: POPs in fish from Ghana (Ntow, et al., 2008)

5.3.4.3. Data from Nigeria

In Nigeria, POP pesticides (Aldrin, DDT and its metabolites DDD and DDE) were detected in fish with residue levels ranging from 0.03 to 0.06ng/g (Ize-Iyamu et al., 2007). These are illustrated in Figure 5. 27 and Annex E Table E 76.

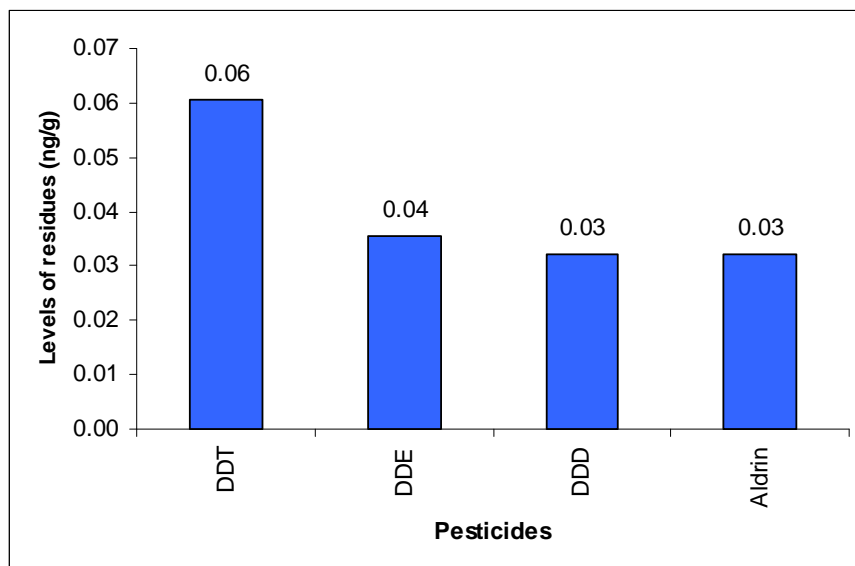


Figure 5.27: POPs in fish from Nigeria (2007)

5.3.4.4. Data from Tanzania

In a study in Tanzania, dieldrin, DDT and its metabolites (DDD and DDE) were detected in fish. The concentration of DDE was the highest compared to other pesticides analysed (Figure 5.28 and Annex E Table E 77).

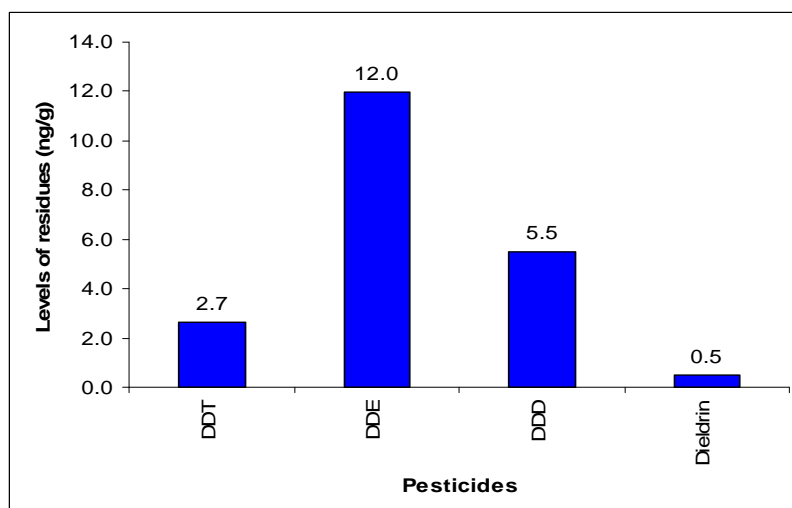


Figure 5.28: POPs in fish from Tanzania (Mwevura et al., 2002)

5.3.5. POPs levels in crops

5.3.5.1. Data from Ghana

In a study conducted to determine pesticide residues in tomatoes from farms and markets in Ghana, the concentrations of DDT, DDE, DDD, aldrin, dieldrin and HCB were below detection limit except heptachlor which had concentration of 1.65ng/g (Annex E Table E 71) (Ntow, 2001).

5.3.6. Discussion of POPs residues in other media

Assessment of the reported POPs levels in other media reveal varying concentrations of DDT and its metabolites, and other pollutants such as Mirex, Aldrin, Dieldrin, Endrin, HCB, Heptachlor in sediment, water meat, fish, and crops. The concentration of DDT residues was two times higher than the WHO Maximum Residue Levels (MRLs) in meat (fat and lean) in some report from the region. Therefore, there is a need for monitoring of these residues in the the region.

Although all POP pesticides have been detected in environmental samples in the region, DDT and its metabolites seems to be the most frequently reported in most of the studies. For instance, in a study by Darko et al. (2008) aimed at establishing the extent of conatamination of fish (*Tilapia zilli*), sediments and water from Lake Boswomtwi, by organochlorine pesticides, DDT and DDE were found in sediments with concentrations of 4.41 ng/g and 8.34 ng/g, and in fish with concentrations of 3.65 ng/g and 5.32 ng/g respectively. Determination of the rarios of DDE and DDT established that DDT was lower than DDE, which implied contamination due to the past usage of DDT.

However, although the concentrations of DDT residues and other POPs pesticides (Aldrin, Dieldrin, Endrin, HCB, Heptachlor and Mirex) reported were generally low in water and soil samples in many African countries (Manirakiza et al., 2003), in some countries like Tanzania, the ratio of DDT metabolites to total DDT showed evidence of recent use of DDT in some areas (Mwevuera et al., 2002). In addition, according to authors in Nigeria, the levels of OCPs in water and fish are on the increase, and there is a serious need for the monitoring of these POPs in water, food and environment in order to prevent various environmental and public health hazards (Ize-Iyamu et al., 2007).

The existing POPs research data, in the region, show the presence of DDT and its metabolites, and other POPs such as aldrin, dieldrin, endrin, HCB, heptachlor and mirex in water, sediments and other environmental compartments. Although, the reported levels showed variation from one country to the other, the data were obtained from research activities conducted at different times, with different objectives, and applying different methodologies. The situation points out the necessity of harmonised POPs monitoring programmes for water, food and other environmental media in the region, in order to obtain a more comparable regional environmental quality data that can be used to measure temporal trends and spatial distribution in the region.

5.4. EVALUATION OF LONG RANGE TRANSPORT OF POPS IN THE REGION

5.4.1 Discussion of back trajectories

Trajectories were generated for all countries using one sampling site per country. In countries with multiple sites, two backgrounds were selected for trajectory analysis wherever possible. It has to be noted however, that although back trajectories can indicate the source areas for background sites, they cannot serve the purpose of source identification in the industrial or residential areas with strong local emission sources (like Egypt or Senegal, in this study).

While in some countries (such as Ghana and Kenya) the trajectories seemed to be quite consistent over the whole sampling period, their patterns varied greatly between the individual sampling months in other countries (Ethiopia, Mali, Sudan). Figures 5.29 and 5.30 illustrate the results of backtrajectories in Kenya and Mali respectively.

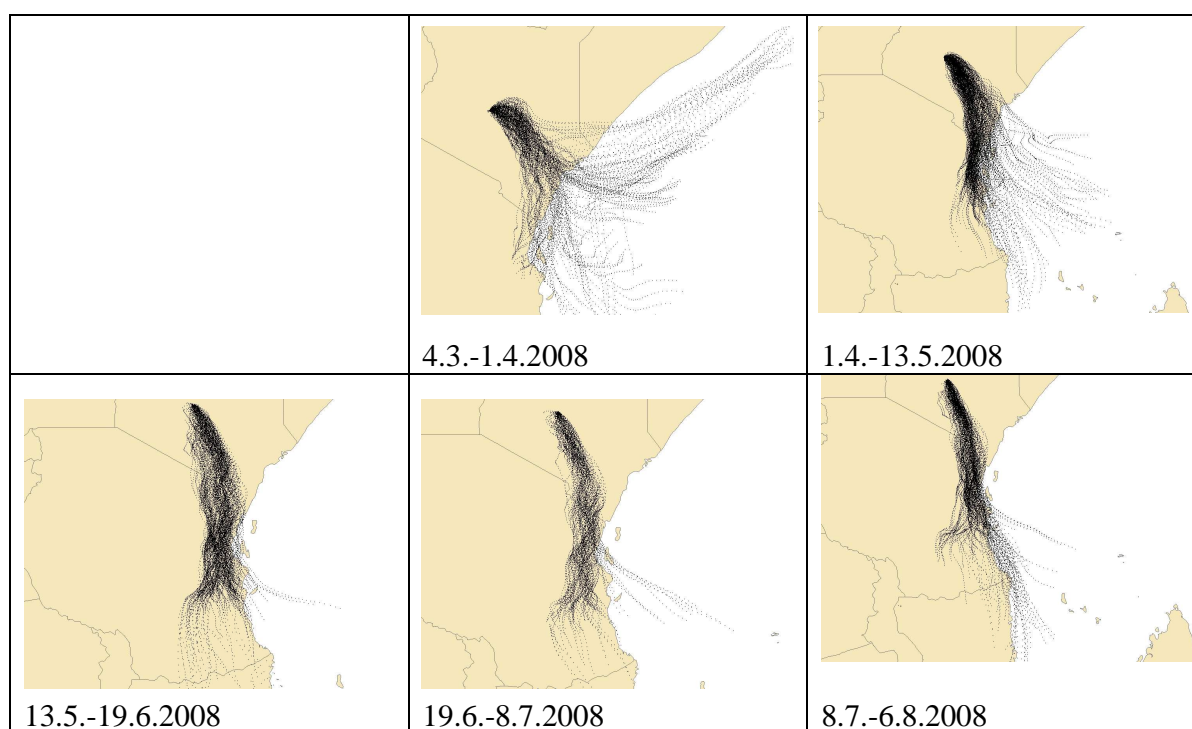


Figure 5.29: Variability of the back trajectories for Mt. Kenya (Kenya) in a six months sampling period (March – August, 2008)

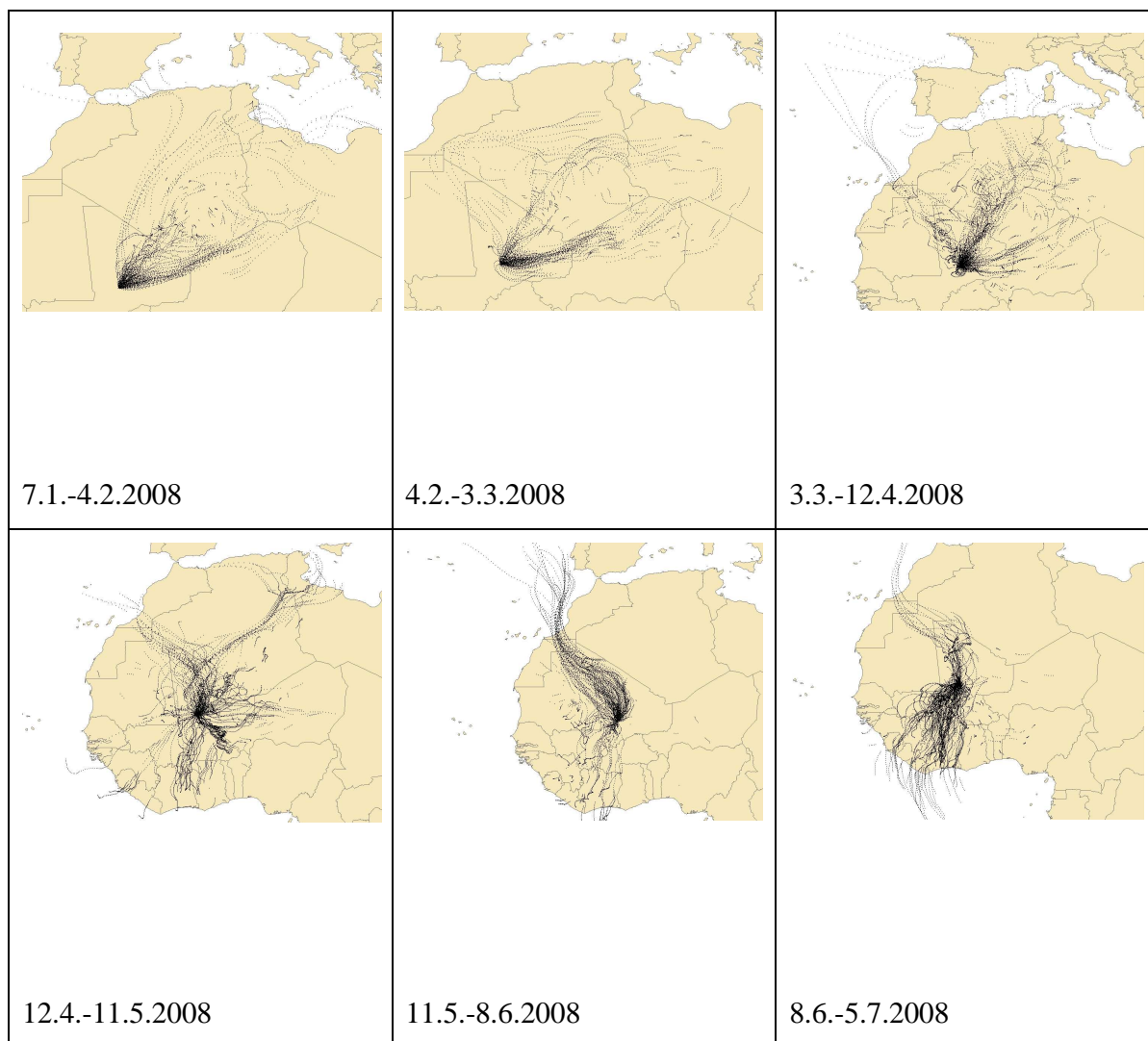


Figure 5.30: Variability of the back trajectories for Tombouctou (Mali) in a six months sampling period (January – July, 2008)

Additional results of back trajectories for other countries are shown in Annex E Figures E36 to E51). However, it is important to note that further information on local climatology and meteorology is needed to analyze correctly the relationship between the variability of the atmospheric POPs and the back trajectories. Temperature, sunshine, wind speed or wet deposition are some of the factors affecting the fate and life time of the compounds in the atmosphere (together with local and distant sources).

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. CONCLUSIONS

6.1.1. Levels of contamination of core media by POPs in African region

This report summarises the findings of POPs levels in core media and other media from Africa. Ambient air data were derived from model monitoring networks based on the passive sampling technique. Human milk data were mainly from WHO human milk surveys, whereas data for other media were mainly from research activities within the region.

6.1.1.1. Contamination of the ambient air

The air samples from 26 sampling sites in 15 countries of the African continent were collected during the 6 months of the pilot MONET-AFRICA survey. The sites ranged from rural and urban backgrounds to sites contaminated by industrial activities and obsolete pesticides.

It was proved that several sites (Mt. Kenya in Kenya, Tombouctou in Mali, Molopo nature reserve or Barberspan in South Africa, Reduit in Mauritius) are good candidates for future background monitoring of POPs in the continent.

It was also shown that levels of various chemicals range over several orders of magnitude and strong primary and secondary sources of atmospheric contamination could be identified.

The industrial site in Egypt presented a problem of heavy PCDD/F contamination in urban areas. Together with Ethiopia, Egypt also drew attention to extremely high atmospheric levels of PAHs associated with combustion processes. Similarly, Senegal had a site representing heavy contamination of PCBs, PAHs and PCDDs/Fs.

Kitengela in Kenya elucidated the problem of the obsolete pesticide storages sites, with very high atmospheric levels of DDTs, HCHs and HCB.

Low *p,p'*-DDE/*p,p'*-DDT ratios were observed at many sampling sites in the region, and indicated a problem that could be associated to the recent usage of DDT.

Several sites in the region showed month-to-month variabilities in pesticide concentrations ranging over orders of magnitudes, suggesting fresh applications, especially of the currently used pesticides such as lindane and endosufan.

MONET-Africa project established not only the baselines of the POP levels in the African continent but also a partnership between the scientists and institutions in 15 participating countries of the region and their strategic partner in the Czech Republic, and the concept ought to be further developed.

All these findings should be considered when planning not only future monitoring programs but also national regulations and implementation plans.

6.1.1.2. Contamination of human tissues (milk and/or blood)

The main POPs human milk data were obtained from the 3rd and 4th rounds of WHO human milk surveys. The 3rd round WHO milk survey data were for the samples submitted by Egypt, and only constituted of a summary of WHO-PCDD/F-TEQ, and WHO-PCB-TEQ. The 4th round human milk survey data were for the samples submitted by Sudan and covered all the POPs groups (pesticides, PCBs, dioxins and furans) in Annexes A, B and C of the Convention. The data showed human milk contamination by an array of POPs at varying concentrations. All indicator PCBs concentrations were of quantifiable levels, whereas of all the POP pesticides, aldrin, endrin, toxaphene and mirex were not detected. A number of PCDDs and PCDFs were also detected.

Additional data for human blood and breast milk were obtained from research activities within the region, and mainly covered POP pesticides. The POPs levels in human milk data from the region showed varying concentrations from one country to another, attributed to differences in socio-economic, industrial and agricultural activities taking place.

Additional data was to be obtained from UNEP/WHO milk survey, a supplementary data collection activity initiated in 2008, to fill the envisaged human milk data gaps in the region for the first effectiveness evaluation.

6.1.2. Levels of contamination of other media by POPs in African region

Through investigation of POPs monitoring data collected in the African region, it is apparent that there is resident skill for POPs monitoring in various countries at the Universities and research institutions. However, there is lack of regional monitoring programmes with harmonized monitoring protocols for provision of comparable data. Therefore, to facilitate generation of reliable and comparable data in the future, it will be important to establish monitoring programmes that cut across several countries, with similar protocols for POPs measurement not only in core media but also in other media. There is need for regional media to be included as matrices of interest for future evaluations. It is important to supplement the existing laboratory equipment to support the existing human resources to generate reliable in the monitoring programmes.

6.1.2 Summary of temporal trends of POPs levels in the region

Background levels of POPs were established in various sub-regions of Africa, and levels were found to vary from one period to another for all sites. Although the samples collected over a six months period allowed partial analysis concentrations of POPs, absence of sufficiently long-term regional monitoring programmes did not allow a comprehensive investigation and evaluation of temporal trends of POPs in the region that would address influence of climatological and metrological factors as well as human activities.

MONET-Africa project also served the purpose of the capacity building in the African continent. Educational and training activities included international summer school for the project participants. Parallel samples were also collected at most of the sites for development of the methods and quality control in local laboratories.

6.1.3 Summary of Longrange transport

Preliminary analysis of back trajectories was conducted using the air samples collected over a six months period, from 15 countries in the region that participated in MONET Africa pilot project implemented in 2008. The patterns of monthly trajectories varied from one country to another, and while in some countries the trajectories seemed to be quite consistent over the whole sampling period, in others the patterns varied greatly between individual sampling months.

Considering the fact that back trajectories only indicate the source areas for background sites, and cannot serve the purpose of source identification in industrial or residential areas with strong local emission sources, the short period of sampling could not allow comprehensive evaluation of the influence of longrange transport on the levels of POPs in the region. In addition, more information on local climatology and meteorology is needed to analyze correctly the relationship between the variability of the atmospheric POPs and the back trajectories.

6.1.4. Summary of gaps in data coverage and resources needed for capacity enhancement

6.1.4.1 Summary of gaps in data coverage

Most of the core media POPs monitoring data were obtained through the strategic data collection activities established in 2008. In this regard, quantitative comparisons of the levels across countries were very difficult, due to lack of adequate data and their completeness, and the short period for sampling activities. Generally, the region lacks long-term established monitoring programs with good regional spatial representation to comprehensively address spatial distribution, the temporal trends in concentrations, long-range transport.

In this regard, the following were identified as key data gaps: inadequate milk data for some sub-regions; lack of systematic monitoring of POPs in the core media (ambient air and human milk or blood); lack of data on PCDD/PCDF; and very limited data on PCBs.

6.1.4.2. Resources needed for capacity enhancement needs

In order to address the existing data gaps, capacity building for POPs monitoring remains of a high priority for most of the countries and the region at large. These include: building human capacity to analyse and manage POPs, support for dedicated regional laboratories with necessary high resolution equipment for analysis of all POPs compounds; support for regional approach to POPs monitoring by establishing regional programmes with standardized protocols for determination of POPs in core media and non core media; provision of basic consumables and equipment to national laboratories to support their involvement in regional programmes; involvement of national regional institutions in proficiency testing and upgrading their performances in POPs analysis; promoting of regional data sharing and storage; support sample banking for future evaluations; and strengthening communication among the regional organization groups and focal points through Chemical Information Exchange Network (CIEN) and similar efforts.

6.1.5. Summary of ongoing programmes/Activities in the region

Africa region collaborated with the following programmes and strategic partners to obtain data on core media: MONET-Africa project coordinated by RECETOX (Czech Republic), Global Atmospheric Passive Sampling (GAPS) programme coordinated by Environment Canada for ambient air data, and the World

Health Organization (WHO) for human milk data. These strategic partners have consolidated expertise in their respective areas for sampling, analysis, and interpretation of results in accordance with the criteria contained in the Implementation Plan for the First Effectiveness Evaluation.

Of the three programmes, GAPS monitoring is ongoing in a few countries, whereas MONET Africa project virtually stopped after the six months in most of the countries. On the other hand, although WHO is conducting analysis of the human milk samples collected in 2008, the surveys are periodic in nature, and a break in samples collection is expected temporarily until the next round of survey. In this regard, there is urgent need for support to enable continuation of MONET Africa monitoring programme; widen the coverage of GAPS monitoring activities in the region; and facilitate parties to participate in the next rounds of WHO human milk surveys.

In addition, some academic and research institutions within the region, have ongoing research activities mainly covering other media, and only addressing the core media to a limited extent.

6.1.6 Summary of monitoring arrangements for future effectiveness evaluation.

Based on the lessons learnt from the First Effectiveness Evaluation, future evaluations can be improved by: 1) maintaining on-going monitoring programmes to support generation of baseline data in the region, 2) maintaining and enhancing regional coverage of the established strategic programmes to provide additional data in the core media, 3) continued POPs monitoring to produce comparable data to support the assessment of trends and levels determined in the core media, as well as at least one additional medium of regional priority, 4) incorporation of candidate persistent organic pollutants into the monitoring programmes, 5) enhancing participation of regional institutions and laboratories through the analysis of parallel samples, 6) facilitation of inter-laboratory calibration and training activities, 7) establishing a regional specimen bank and database for the core media, and 8) strengthening communication network among the ROG members, the Convention focal points and official national contacts.

6.2. RECOMMENDATIONS

The following are some important recommendations that are cost effective and will serve as a way forward for future monitoring programs. There is a need to:

- a) strengthen and widen partnership collaboration in GMP and other related activities, to cover more countries in Africa;
- b) provide additional financial support to maintain established GMP activities in the region while strengthening national and regional laboratories;
- c) strengthen the capacity of identified national and regional laboratories to conduct POP analyses;
- d) establish regional programs for the production of data to fill the existing gaps;
- e) standardize protocols used in POPs monitoring;
- f) strengthen the capacity of existing regional structures such as the Stockholm Convention/Basel Regional Centres;
- g) form National Task Forces on GMP, comprising of Stockholm Convention Focal Points, representatives from WHO, FAO, Nutrition Agencies/ Institutions, and other concerned bodies as a cost effective approach;
- h) involve regional structures such as NEPAD and others dealing with environmental and health issues in the GMP Project implementation;
- i) incorporate regional approaches to the management of hazardous chemicals in relation to environmental and health issues on the continent;

- j) maintain the GMP activities over a longer period so as to determine long range transport and temporal trends of POP levels in the region;
- k) strengthen national and regional programs to include POP monitoring;
- l) mainstream chemical management, such as POP monitoring, into the national and regional development agenda;
- m) Forge close links with programs with more or less similar objectives such as the Regionally Based Assessment of PTS;
- n) Potential partners for follow-up activities should be identified and the best sampling sites for regional monitoring based on the results of the pilot studies;
- o) Intercalibration studies should be organized to compare and assure the analytical quality of participating laboratories;
- p) Parallel samples should be analyzed in the laboratory of the strategic partner, who is also capable of providing educational and training support;
- q) Training courses or summer schools focused on the data interpretation and visualization, statistical analysis, modeling and geographic information system should be organized with support to regional centers in Africa in cooperation with the strategic partners.

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ANNEX A

Table A 1: Signatory or Party countries to the Stockholm Convention as of 03/08/2008

Entry #	COUNTRY	NIP TRANSMITTED (Between 2006-2008)	SIGNATORIES	PARTIES
01	Algeria	X	X	X
02	Angola	—	—	X
03	Benin	—	X	X
03	Botswana	—	—	X
04	Burkina Faso	X	X	X
05	Burundi	X	X	X
06	Cameroon	—	X	—
07	Cape Verde	—	—	X
08	Central African Republic	—	X	—
09	Chad	X	X	X
10	Comoros	X	X	X
11	Congo	X	X	X
12	Côte d'Ivoire	X	X	X
13	DRC	—	—	X
14	Djibouti	X	—	X
15	Egypt	X	X	X
16	Eritrea	—	—	X
17	Ethiopia	X	X	X
18	Gabon	—	X	X
19	Gambia	—	X	X
20	Ghana	X	X	X
21	Guinea Bissau		X	
22	Guinea		X	—
23	Kenya	X	X	X
24	Lesotho			X
25	Liberia	—	—	X
26	Libya	—	—	X
27	Madagascar	—	X	X

28	Malawi	—	X	—
29	Mali	X	X	X
30	Mauritania	—	X	X
31	Mauritius	X	X	X
32	Morocco	X	X	X
33	Mozambique	—	X	X
34	Namibia	—	—	X
35	Niger	—	X	X
36	Nigeria	—	X	X
37	Rwanda	X	—	X
38	Saint Tome & Principe	X	X	X
39	Senegal	X	X	X
40	Seychelles	—	X	X
41	Sierra Leone	—	X	X
42	South Africa	—	X	X
43	Sudan	X	X	X
44	Swaziland			X
45	Togo	X	X	X
46	Tunisia	X	X	X
47	Tanzania	X	X	X
48	Uganda	—	—	X
49	Zambia	—	X	X
50	Zimbabwe	—	X	—

SC Stockholm Convention

X Act effected

— Act not effected

Table A 2: Chemicals in Annex A of the Stockholm Convention

Chemical	Activity	Specific exemption
Aldrin* CAS No: 309-00-2	Production	None
	Use	Local ectoparasiticide Insecticide
Chlordane* CAS No: 57-74-9	Production	As allowed for the Parties listed in the Register
		Local ectoparasiticide Insecticide Termiticide Termiticide in buildings and dams Termiticide in roads Additive in plywood adhesives
Dieldrin* CAS No: 60-57-1	Production	None
	Use	In agricultural operations
Endrin* CAS No: 72-20-8	Production	None
	Use	None
Heptachlor* CAS No: 76-44-8	Production	None
	Use	Termiticide Termiticide in structures of houses Termiticide (subterranean) Wood treatment In use in underground cable boxes
Hexachlorobenzene CAS No: 118-74-1	Production	As allowed for the Parties listed in the Register
	Use	Intermediate Solvent in pesticide Closed system site limited intermediate
Mirex* CAS No: 2385-85-5	Production	As allowed for the Parties listed in the Register
	Use	Termiticide
Toxaphene* CAS No: 8001-35-2	Production	None
	Use	None
Polychlorinated Biphenyls (PCB)*	Production	None
	Use	Articles in use in accordance with the provisions of Part II of this Annex

Table A 3: Chemicals in Annex B of the Stockholm Convention

Chemical	Activity	Acceptable purpose or specific exemption
DDT (1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane) CAS No: 50-29-3	Production	Acceptable purpose: Disease vector control use in accordance with Part II of this Annex Specific exemption: Intermediate in production of dicofol Intermediate
	Use	Acceptable purpose: Disease vector control in accordance with Part II of this Annex Specific exemption: Production of dicofol Intermediate

Table A 4: Chemicals in Annex C of the Stockholm Convention

Chemical
Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF) Hexachlorobenzene (HCB) (CAS No: 118-74-1) Polychlorinated biphenyls (PCB)

ANNEX B

Western Africa

Benin
Burkina Faso
Cape Verde
Côte d'Ivoire
Gambia
Ghana
Guinea
Guinea-Bissau
Liberia
Mali
Mauritania
Niger
Nigeria
Senegal
Sierra Leone
Togo

Central Africa

Cameroon
Central African Republic
Chad
Congo
Democratic Republic of
Congo
Equatorial Guinea
Gabon
Sao Tomé and Príncipe

Eastern Africa

Burundi
Djibouti
Eritrea
Ethiopia
Kenya
Somalia
Rwanda
Uganda

Southern Africa

Angola
Botswana
Lesotho
Malawi
Mozambique
Namibia
South Africa
Swaziland
United Republic of
Tanzania
Zambia
Zimbabwe

**Northern Africa**

Algeria
Egypt
Libyan Arab Jamahiriya
Morocco
The Sudan
Tunisia

Western Indian Ocean Islands

Comoros
Madagascar
Mauritius
Réunion (France)
Seychelles

Figure B 1: Sub-regions of Africa Continent (Source: UNEP, 2002b)



Figure B 2: Africa Climate Map (Source: www.worldbook.com/.../climates/african_climate 15/03/2009)

ANNEX C

Table C 1: Template used for collection of human milk POPs data

COUNTRY NAME NAME OF CONTACT PERSON INSTITUTION ADDRESS TELEPHONE EMAIL																					
Template form for reporting data on human milk/blood POPs levels – for each data sets use a separate form (copy this excel sheet) –																					
Explanatory notes (for more details see "Notes" sheet): – Fill in coloured cells – Delete HUMAN MILK or HUMAN BLOOD, YES or NO, etc. – If no information is available (incl concentrations) leave particular cells void – If a congener was present below the LOD (e.g. 0.5) insert <0.5																					
Matrix: <input type="checkbox"/> HUMAN MILK <input type="checkbox"/> HUMAN BLOOD																					
Within which activities were samples collected and analysed:																					
Sampling site:																					
Is the site highly contaminated with some of the POPs? <input type="checkbox"/> NO <input type="checkbox"/> YES																					
Samples collected in years:																					
Pooled sample: <input type="checkbox"/> NO <input type="checkbox"/> YES If yes, how many samples were pooled:																					
Number of donors: Percentage of males [%]:																					
Average age of the donors: The lowest age in this data set: The highest age in this data set:																					
Percentage of the donors consuming predominantly local eggs/meat/fish/plants:																					
Analyses performed by HRGC hyphenated with: <input type="checkbox"/> ECD <input type="checkbox"/> HRMS <input type="checkbox"/> LRMS <input type="checkbox"/> LRMS-MS																					
Were QA/QC procedures applied for sampling and analysis: <input type="checkbox"/> YES <input type="checkbox"/> NO																					
Lipid determination:																					
Concentration [ng/g lipid]																					
Sample No. (Code)	Aldrin	Chlordane group				Dieldrin	DDT group						Endrin	HCB	Heptachlor group		Mirex				
		Chlordane		Nonachlor			oxy-chlordane	4,4'-DDT	4,4'-DDE	4,4'-DDD	2,4'-DDT	2,4'-DDE			2,4'-DDD	Heptachlor					Heptachlor epoxide
		cis-	trans-	cis-	trans-																
1																					
2																					
3																					
4																					
5																					
Concentration [pg/g lipid]																					
Toxaphene			Indicator PCBs						Dioxin-like PCBs												
#26	#50	#62	#28	#52	#101	#138	#153	#180	#77	#81	#105	#114	#118	#123	#126	#156	#157	#167	#169	#189	
1																					
2																					
3																					
4																					
5																					
Concentration [pg/g lipid]																					
PCDDs								PCDFs													
2378-TCDD	12378-PeCDD	123478-HxCDD	123678-HxCDD	123789-HxCDD	1234678-HpCDD	OCDD	2378-TCDF	12378-PeCDF	23478-PeCDF	123478-HxCDF	123678-HxCDF	234678-HxCDF	123789-HxCDF	1234678-HpCDF	1234789-HpCDF	OCDF					
1																					
2																					
3																					
4																					
5																					

Table C 2: Template used for collection of ambient air POPs data

COUNTRY NAME NAME OF CONTACT PERSON INSTITUTION ADDRESS TELEPHONE EMAIL																					
Template form for reporting data on ambient air POPs levels – for each data sets use a separate form (copy this excel sheet) –																					
Matrix: ACTIVE SAMPLING PASSIVE SAMPLING Within which activities were samples collected and analysed:										Explanatory notes (for more details see "Notes" sheet): – Fill in coloured cells – Delete ACTIVE or PASSIVE SAMPLING, YES or NO, etc. – If no information is available (incl concentrations) leave particular cells void – If a congener was present below the LOD (e.g. 0.5) insert <0.5											
Sampling site: Is the site highly contaminated with some of the POPs? NO YES Samples collected in years:																					
Site localisation and description: Analyses performed by HRGC hyphenated with: ECD HRMS LRMS LRMS-MS Were QA/QC procedures applied for sampling and analysis: YES NO																					
Concentration [ng/m3 or ng/filter]																					
Sample No. (Code)	Aldrin	Chlordane group				Dieldrin	DDT group						Endrin	HCB	Heptachlor group		Mirex				
		Chlordane		Nonachlor			oxy-chlordane	4,4'-DDT	4,4'-DDE	4,4'-DDD	2,4'-DDT	2,4'-DDE			2,4'-DDD	Heptachlor					Heptachlor epoxide
		cis-	trans-	cis-	trans-																
1																					
2																					
3																					
4																					
5																					
Concentration [ng/m3 or ng/filter]																					
Toxaphene			Indicator PCBs							Dioxin-like PCBs											
#26	#50	#62	#28	#52	#101	#138	#153	#180	#77	#81	#105	#114	#118	#123	#126	#156	#157	#167	#169	#189	
1																					
2																					
3																					
4																					
5																					
Concentration [ng/m3 or ng/filter]																					
PCDDs							PCDFs														
2378-TCDD	12378-PeCDD	123478-HxCDD	123678-HxCDD	123789-HxCDD	1234678-HpCDD	OCDD	2378-TCDF	12378-PeCDF	23478-PeCDF	123478-HxCDF	123678-HxCDF	234678-HxCDF	123789-HxCDF	1234678-HpCDF	1234789-HpCDF	OCDF					
1																					
2																					
3																					
4																					
5																					

Table C 3: Summary of responses received on existing capacity for Analysis of POPs

Country	POPs lab	Dioxin lab	Air sampling capacity	Provide capacity strengthening QA/QC	Assistance capacity
Congo (Rep. of)	No POPs				
Egypt	X	X in food	Need samplers Would like to start		
Ethiopia	X-OCPs,		pas		
Ghana	X-OCPs, PCBs		Air quality monitoring		
Kenya	X- OCPs PCBs		Need samplers Would like to start	X	X
Mali	X-OCPs				
Mauritius	X- OCPs PCBs		HV?		
Morocco	X-OCPs PCBs				
Mozambique					
Nigeria	X-OCPs, PCBs		pas		
Senegal	X-OCP, PCBs				
Sierra Leone	x-OCP dormant				
South Africa	X-OCPs PCBs	limited	Pas, HV		
Sudan	X-OCPs				
Tanzania	X-OCPs, PCBs		Pas &HV	No QA/QC for POPs	Sampling and testing of OCPs and PCBs
Togo	X OCP, PCBs			Accredited labs could	
Uganda	X-OCPs, PCBs		Pas		
Zambia	X-OCPs, PCBs		Pas		
Gambia			Pas		
Tunisia	X-OCPs, PCBs				

Table C 4: Summary of national monitoring activities in the region

Country	Background air		Human		Note	Period
	HV	PAS	Blood	Milk		
Congo (Rep. of)					No laboratory for POPs analysis	
Egypt				X	Milk data and blood data are available also for 2006	3rd WHO
Ethiopia				x-1990	Milk	
Ghana				X	Milk and blood data from research, OCP residues in food, agriculture, products, soil, fish	
Kenya				X	water, sediments, vegetation, fish, and soils, bivalves	Milk only research based 1986, 1992 and 2004
Mali					OCP residues in food, soil, water	
Mauritius					OCP residues in agricultural products, fish, water soil	
Morocco						
Mozambique					Water, fish, soil,	
Nigeria				x-old	OCPs in Food, soil, water, fish	Milk data from 1986
Senegal					Water, soil, vegetables, food; SOP and QA/QC	
Sierra Leone					Organochlorines in fish and shellfish from a study 1985-1988(also Ghana and Nigeria)	
South Africa		X	x	X	Human samples from specific research (also reference samples from clean regions) GAPS passive sampling, soil, sediments, eggs,	
Sudan			x-1996		Residues in food, soil, agricultural products	
Tanzania					Has capacity for air sampling ;POPs in water, soil fish	
Togo					Water, soil and sediments and plants as research work (2005)	
Uganda			x	x-1996	Some research sampling and analysis of human media 2005; food, soil, sediment	
Zambia						

Table C 5: TORs for Consultants who drafted the regional POPs monitoring report

A)	Terms Description
1	The consultant will compile all the readily available POPs data and the supplementary data generated from the Africa region, conduct necessary statistical analysis and present the data in appropriate format recommended for the Global monitoring report for Africa region.
2	<p>The consultant will draft the Global monitoring report for the Africa region in the manner recommended by the Stockholm secretariat: Specifically the report should include the following components:</p> <ul style="list-style-type: none"> • Introduction covering the objectives of Article 16 of the Stockholm Convention and of the Global Monitoring Plan (GMP). • Description of the Africa region covering overall composition of the region, political, geographical, links to POPs, industrial activities, agriculture and regional boundaries. • Description of the organizational arrangements made in the Africa region to facilitate the implementation of GMP • Description of the methodology for sampling, analysis and handling of data used in the implementation of GMP in Africa region. • Description of the arrangements made to oversee the preparation of the monitoring report in Africa region. • Description of the results of the substances in Annexes A, B and C of the Stockholm Convention and description of the historical and current sources, regional considerations, trends in environmental levels reported elsewhere; identification of data gaps and capacity development needs to fill the gaps; review of levels and trends to support subsequent effectiveness evaluations. • Summary of findings of the GMP in Africa Region providing a clear and concise synopsis of the results of the Global POPs Monitoring Programme to be used by the Conference of the Parties for effectiveness evaluation of the Stockholm convention. • References to the literature covered in the preparation of the report.
3	The consultant will circulate the first draft of the GMP report for Africa region to the ROG members and parties for comments and endorsement according to the agreed time plan.
4	The consultant will effect the necessary corrections made by the ROG members and the parties to the draft report and submit the final report to the University and the ROG members for publication according to the agreed time plan and the format recommended by the Stockholm Secretariat for the Global Monitoring Report for Africa Region.
5	The consultant will offer necessary advice to the ROG members and participate in the ROG workshop(s) to facilitate the drafting of the Global monitoring report for Africa region.
B)	Work plan and time table
1	All readily available data and information compiled by: March 2008 . Supplementary monitoring activities are performed and additional monitoring data is made available to the drafting team upon becoming available. Placeholders to include additional data to be kept
2	Electronic template to facilitate harmonized drafting of the report is available: April 2008
3	The first draft ready for discussion with the ROG members: June 2008
4	Circulation of the draft regional monitoring report to the ROG members and parties for review and comments: July 2008
5	Correction of the first draft, implementation of the comments and circulation of the final regional monitoring report for endorsement by parties: August 2008
6	Publication of the final regional monitoring report: September 2008
7	Submission of the final report to the Secretariat: 15 th October 2008

ANNEX D

Table D 1: MONET Africa project organization, work plan and Time frame

A) project work plan and time frame (Project duration: January 2008 – December 2008)	
1	Selection of the participating countries and training of the local personnel – a workshop in Nairobi, Kenya: November, 2007.
2	Selection of the sampling sites: November-December, 2007.
3	Distribution of the samplers, filters, sampling protocols, and standard operational procedures: December, 2007.
4	Beginning of the sampling campaign: January, 2008.
5	Frequency and duration of the sampling campaign: 6 sampling periods, 28 days each.
6	Number of sites: 5 per country in Mali and Kenya, 2 in Ghana, 3 in the South Africa, one per country in all the others. 50 sampling sites in the Czech Republic serves as a reference region.
7	Termination of the sampling campaign: August, 2008.
8	Transport of the air and soil samples to Brno: first three months - April, 2008, second three months – July, 2008.
9	Sample preparation and analysis (for polycyclic aromatic hydrocarbons, chlorinated pesticides, polychlorinated biphenyls and polychlorinated dibenzo- <i>p</i> -dioxins and furans): April-August, 2008.
10	Data evaluation and interpretation, final report, scientific papers, web presentation – September-December, 2008.
11	First presentation of the project results: Dioxin 2008, Birmingham.
12	Selection of the background sites in the African region suitable for continuous monitoring, establishment of the regional background network: 2009.
13	Design of the local monitoring projects if needed, technical support, transfer of know-how: 2009.
B) Project management structure:	
1	Project managers: Ivan Holoubek, Jana Klánová
2	Passive air sampler: Jiří Kohoutek
3	Sample preparation: Ivana Poláková, Eva Krejčí
4	Sample analysis: Jana Klánová, Radovan Kareš, Petra Příbylová
5	PCDDs/Fs analysis: Tomáš Tomšej, Tomáš Ocelka
6	QA/QC Manager: Romana Kostrhounová
7	Data processing and visualization: Pavel Čupr, Jana Borůvková, Alice Dvorská
8	Scientific advisors: Kevin C. Jones (Lancaster University), Tom Harner (Environment Canada)

Table D 2: List of MONET Africa project participants and their contacts

County	Institution	Contact person	E-mail
Czech Republic	RECETOX , Masaryk University Brno	Ivan Holoubek Jana Klánová	holoubek@recetox.muni.cz klanova@recetox.muni.cz
Kenya	Department of Chemisty, University of Nairobi, P. O.	Vincent O. Madadi	vmadadi@uonbi.ac.ke madadivin2002@yahoo.com
Congo (Republic of)	CRCRT BP 177 Brazzaville, Congo	Jean de Dieu Nzila Urbain Gampio	jddnzila@yahoo.fr muga68@yahoo.fr
Egypt	Egyptian Environmental Affairs Agency (EEAA), Ministry of State of	Mohammed Ismail Ibrahim	mis641@hotmail.com
Ethiopia	Federal Environmental Protection Authority	Habamu Wodajo Mohammed Ali	habwodajo@yahoo.com epol@ethionet.et
Ghana	Environmental Protection Agency	Sam Adu-Kumi, Principal	adukumisam@yahoo.com, sakumi@epaghana.org
Mali	Laboratoire central vétérinaire BP 2295	Traoré Halimatou Koné	halimatoutraore@yahoo.fr
Mauritius	Department of Environment, Ministry of Environment &	Ram Seenauth	rseenauth@mail.gov.mu
Nigeria	Federal Ministry of Environment, Housing & Urban Development	Stella Uchenna Mojekwu	sumojekwu@yahoo.com
Senegal	Direction de l'Environnement et des Etablissements Classés, 106 Rue Cornet, DAKAR	Ousmane SOW	Ousmane7@aim.com Ousmane7@orange.sn
South Africa	School of Environmental Sciences and Development (Zoology) North-West	Henk Bouwman	Henk.bouwman@nwu.ac.za
Sudan	Occupational Hygiene Department, Federal Occupational Health	Sitt Nour Hassan Mohamed Hassan	sitnour@yahoo.com
Togo	Université de Lomé BP 20131 Lomé Togo	Komla Sanda Djeri-Alassani	komsanda@hotmail.com bdjeri@hotmail.com
Tunisia	International Centre for Environmental Technologies CITET, Boulevard de Leader	Ramzi Ben Fredj	unite-cho@citet.nat.tn
Zambia	Environmental council of Zambia	David Kapindula	dkapindula@necz.org.zm

Table D3: Description of MONET Africa passive air sampling sites in Africa

SAMPLING SITE	CLASSIFICATION	COUNTRY	CODE	LATITUDE	LONGITUDE	ALTITUDE
Prstím de Brazaville	Urban	Congo	CON01	-4.281250	15.243639	298
Kinshasa, Univ. campus, Faculty of Science	Urban	DR Congo	DRC01	4.4186111	15.3086111	437
Kinshasa, Univ. camp., garden	Urban		DRC02	4.4175000	15.3091667	441
Kinshasa, Univ. camp., library	Urban		DRC03	4.4216667	15.3088889	451
Kinshasa, Univ. camp., parish	Urban		DRC04	4.4216667	15.3100000	450
Kinshasa, Univ. camp., ERAIFT	Urban		DRC05	4.4166667	15.3127778	412
Kinshasa, Univ. camp., ISTM	Urban		DRC06	4.4102778	15.3066667	368
Kinshasa, Univ. camp., UNIKIN	Urban		DRC07	4.4066667	15.3019444	442
Kinshasa, Univ. camp., GSMA	Urban		DRC08	4.4202778	15.3077778	406
Cairo	Urban industrial	Egypt	EGY 01	30.071142	31.315089	50
Asela	Urban background	Ethiopia	ETH 01	7.950000	39.116667	2372
Kwabanya	Urban background	Ghana	GHA 01	5.676389	-0.186667	76
East Legon	Urban background		GHA 02	5.651944	-0.174167	77
Mt. Kenya	Mountain background	Kenya	KEN 01	-0.030000	37.220000	3678
Kabete	Urban background		KEN 02	-1.249444	36.742500	1841
Kitengela	Obsolate pesticide dumpsite		KEN 03	-1.444549	36.988564	1525
Industrial site	Industrial		KEN 04	-1.306573	36.874924	1623
Dandora	Municipal waste dumpsite		KEN 05	-1.243074	36.906166	1625
Tombouctou	Urban background	Mali	MAL01	16.731083	-2.997861	200
Bamako Centre	Urban, waste dumping site		MAL02	12.630000	-8.022000	335
Bamako Int. airport	Suburban background, savana		MAL03	12.533333	-7.950000	366
Koutiala	Agricultural, cotton growing region		MAL04	12.383333	-5.466667	366
Niono	Agricultural, basin of Niger river		MAL05	14.283333	-5.133333	295
Reduit	Background	Mauritius	MAU 01	-20.233203	57.498492	310
Sheda	Agricultural	Nigeria	NIG 01	8.881000	7.062167	229
Dakar	Urban industrial	Senegal	SEN 01	-25.883333	22.883333	1001
Molopo Nature reserve	Background	South Africa	SAF	-26.533333	25.600000	1366
Barberspan	Background		SUF 02	-26.716667	27.883333	1454
Vanderbijl Park	Industrial		SUF 03	-25.450100	29.303160	1594
Khartum	Urban industrial background	Sudan	SUD 01	15.564167	32.513639	390
Koumakonda	Agricultural background	Togo	TOG01	6.950000	0.616667	576
Tunis	Urban background	Tunisia	TUN 01	36.839278	10.219333	3
Lusaka IA	Urban background	Zambia	ZAM 01	-15.316667	28.450000	1150

ANNEX E

Table E 1. Air concentrations (pg/m³) of OCPs, PCBs in 2005 using PUF-disk samplers

Period	Site ID	HEPT	HEPX	TC	CC	TN	Dieldrin	ppDDE	ppDDT	PCBs#
Period1	AF01	BDL	BDL	BDL	BDL	BDL	37	BDL	BDL	35
	AF02	NA	NA	NA	NA	NA	NA	NA	NA	NA
	AF03	BDL	BDL	BDL	BDL	BDL	BDL	2	BDL	BDL
	AF04	BDL	BDL	0.3	0.3	BDL	BDL	BDL	BDL	252
Period2	AF01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	--	63
	AF02	BDL	BDL	5	4	2	141	BDL	--	BDL
	AF03	BDL	BDL	0.5	0.6	0.4	BDL	43.8	--	BDL
	AF04	BDL	BDL	1.4	1.3	1.3	16.1	16.4	--	50
Period3	AF01	BDL	BDL	BDL	BDL	BDL	24	BDL	--	62
	AF02	NA	NA	NA	NA	NA	NA	NA	NA	NA
	AF03	NA	NA	NA	NA	NA	NA	NA	NA	NA
	AF04	BDL	BDL	0.22	0.59	0.11	BDL	BDL	--	BDL
Period4	AF01	NA	NA	NA	NA	NA	NA	NA	NA	NA
	AF02	NA	NA	NA	NA	NA	NA	NA	NA	NA
	AF03	BDL	BDL	BDL	BDL	BDL	BDL	BDL	--	BDL
	AF04	NA	NA	NA	NA	NA	NA	NA	NA	NA
MDL		0.1	0.1	0.1	0.4	0.2	0.14	0.1	0.5	0.12

Sum of 48 PCB congeners

Sum of PBDE-47, 99, 100

NA = PUF disk not deployed during the period/sample not available

MDL = method detection limit (pg/m³)

BDL = below detection limit

Table E 2: Length of sampling in days and amounts of selected organochlorine pesticides sequestered in XAD-based PAS in ng/PAS

Year	Site ID	Days	HEPT	HEPX	TC	CC	TN	Dieldrin	ppDDE	ppDDT
2005	AF01	365	ND	ND	0.1	ND	ND	ND	ND	ND
	AF03	345	ND	ND	0.3	0.3	0.1	ND	8.1	ND
	AF04	389	ND	ND	0.2	0.2	0.2	ND	ND	ND
MDL			0.2	0.1	0.04	0.06	0.09	0.5	0.3	0.3
2006	AF01	365	ND	ND	0.1	ND	ND	ND	ND	ND
	AF03	482	ND	ND	0.1	0.1	0.1	ND	ND	ND
	AF04	364	5.8	ND	0.2	0.1	0.1	ND	ND	ND
	AF05	398	1.3	ND	0.3	0.4	0.3	ND	ND	ND
MDL			0.4	0.4	0.03	0.07	0.04	0.9	-	-

BMDL = below method of detection limit

ND = not detected

MDL = method of detection limit (ng/PAS)

Table E 3: Length of sampling in days and amounts of selected organochlorine pesticides sequestered in XAD-based PAS in pg/m³.

Years	Site ID	Days	HEPT	HEPX	TC	CC	TN	Dieldrin	ppDDE	ppDDT
2005	AF01	365	ND	ND	0.3	ND	ND	ND	ND	ND
	AF03	345	ND	ND	0.9	0.9	0.3	ND	24	ND
	AF04	389	ND	ND	0.5	0.5	0.5	ND	ND	ND
MDL			0.6	0.3	0.1	0.2	0.3	1.2	0.9	0.9
2006	AF01	365	ND	ND	0.3	ND	ND	ND	ND	ND
	AF03	482	ND	ND	0.2	0.2	0.2	ND	ND	ND
	AF04	364	16	ND	0.5	0.3	0.3	ND	ND	ND
	AF05	398	3.3	ND	0.8	1.0	0.8	ND	ND	ND
MDL			1.1	1.1	0.08	0.2	0.1	2.5	-	-

BMDL = below method of detection limit

ND = not detected

MDL = method of detection limit (pg/m³)

Table E 4: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the sampling site in Congo (ex-site ORSTOM de Brazzaville)

CONGO - Orstom de Brazzaville						
	Concentration ng/filter					
Sample code	CON 01 A 01	CON 01 A 02	CON 01 A 03	CON 01 A 06	CON 01 A 07	CON 01 A 08
Collection date	11.1.-11.2.2008	11.2.-11.3.2008	11.3.-8.4.2008	8.4.-6.5.2008	6.5.-3.6.2008	3.6.-1.7.2008
PCB 28	4.5	2.1	1.7	1.2	1.5	1.0
PCB 52	3.0	2.2	2.5	2.0	2.0	0.8
PCB 101	2.2	2.8	1.2	0.8	0.6	0.7
PCB 118	1.0	1.5	0.3	0.3	0.2	0.5
PCB 153	2.6	2.3	2.3	1.3	1.3	1.0
PCB 138	1.5	2.3	1.4	0.7	0.6	0.9
PCB 180	1.3	1.6	0.5	0.5	0.6	2.4
Sum of PCB	16.2	14.7	9.8	6.8	6.8	7.3
alpha-HCH	4.4	1.2	1.6	4.3	4.2	4.2
beta-HCH	0.7	1.4	0.9	1.8	2.3	2.7
gamma-HCH	9.7	11.6	7.6	7.8	6.2	3.9
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	14.7	14.2	10.1	13.9	12.7	10.9
o,p'-DDE	0.7	0.8	0.3	0.5	1.0	0.3
p,p'-DDE	10.1	11.1	6.0	5.8	4.9	3.9
o,p'-DDD	0.4	0.7	0.3	0.6	0.7	0.6
p,p'-DDD	1.6	2.2	1.4	1.6	0.9	0.9
o,p'-DDT	4.6	4.3	2.3	1.3	1.0	0.6
p,p'-DDT	7.2	8.7	4.1	4.4	3.5	2.6
Sum of DDT	24.5	27.7	14.3	14.2	12.0	8.9
PeCB	0.7	1.0	1.0	0.3	0.6	1.7
HCB	1.5	1.7	1.9	1.0	1.9	2.5

Table E 5: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the sampling sites in Democratic Republic of Congo, Kinshasa

DEMOCRATIC REPUBLIC OF THE CONGO - Kinshasa								
	Concentration ng/filter							
Sampling site	DRC Kinshasa Faculty	DRC Kinshasa library	DRC Kinshasa parish	DRC Kinshasa garden	DRC Kinshasa Eraft	DRC Kinshasa ISTM	DRC Kinshasa traffic	DRC Kinshasa GSMA
Collection date	1.4.-28.4.2008	1.4.-28.4.2008	1.4.-28.4.2008	1.4.-28.4.2008	21.5.-19.6.2008	21.5.-19.6.2008	21.5.-19.6.2008	21.5.-19.6.2008
PCB 28	3.4	3.5	3.7	4.0	2.3	1.8	4.2	2.7
PCB 52	11.7	7.1	4.9	7.8	5.9	3.8	19.3	4.8
PCB 101	9.1	6.3	3.9	6.1	4.2	4.2	18.9	4.2
PCB 118	5.1	3.4	2.8	3.7	3.6	2.8	12.0	3.0
PCB 153	5.3	4.4	3.9	4.2	4.3	5.5	19.3	5.8
PCB 138	3.8	4.6	2.4	2.6	3.5	4.4	17.7	4.6
PCB 180	2.4	2.1	1.5	1.9	3.0	4.9	10.9	5.5
Sum of PCB	40.9	31.4	23.1	30.2	26.8	27.4	102.2	30.6
alpha-HCH	2.5	1.5	<LOQ	<LOQ	2.9	2.1	<LOQ	<LOQ
beta-HCH	<LOQ	3.4	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
gamma-HCH	7.5	10.2	14.4	10.3	10.1	12.0	6.5	15.7
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	10.0	15.2	14.4	10.3	13.0	14.1	6.5	15.7
o,p'-DDE	1.4	2.2	2.2	2.6	0.6	0.9	0.8	1.3
p,p'-DDE	25.5	23.1	15.3	22.1	9.7	8.9	7.9	11.5
o,p'-DDD	2.1	3.1	1.3	2.4	0.8	<LOQ	<LOQ	1.1
p,p'-DDD	7.9	7.0	4.5	7.7	3.0	2.6	2.7	3.8
o,p'-DDT	9.3	7.7	3.7	6.3	2.2	1.9	1.9	4.3
p,p'-DDT	39.3	24.1	11.9	27.5	5.9	7.2	6.1	12.0
Sum of DDT	85.6	67.1	38.9	68.6	22.1	21.6	19.4	34.04
PeCB	<LOQ	0.3	<LOQ	0.2	0.8	0.6	0.6	0.3
HCB	1.0	1.4	2.3	1.7	1.5	1.9	0.9	2.9

Table E 6: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the urban sampling site in Egypt, Cairo

EGYPT - Cairo						
Concentration ng/filter						
Sample code	EGY 01 A 01	EGY 01 A 02	EGY 01 A 03	EGY 01 A 04	EGY 01 A 05	EGY 01 A 06
Collection date	7.1.-5.2.2008	5.2.-3.3.2008	3.3.-31.3.2008	31.3.-27.4.2008	27.4.-25.5.2008	25.5.-22.6.2008
PCB 28	4.9	7.3	7.1	7.3	8.1	8.3
PCB 52	5.4	9.1	8.1	7.8	9.9	10.5
PCB 101	3.9	3.9	6.1	6.1	5.9	5.8
PCB 118	3.5	3.9	6.6	5.8	6.5	6.0
PCB 153	3.6	3.6	8.2	5.8	6.6	6.4
PCB 138	1.6	2.4	4.8	2.4	4.0	4.8
PCB 180	2.4	2.4	5.3	3.3	3.8	3.3
Sum of PCB	25.3	32.6	46.4	38.3	44.8	45.1
alpha-HCH	23.5	27.0	31.1	10.9	65.5	57.7
beta-HCH	4.2	5.7	2.7	<LOQ	11.5	7.9
gamma-HCH	6.3	9.2	18.4	23.7	24.8	31.4
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	34.0	41.8	52.1	34.6	101.7	97.0
o,p'-DDE	0.5	1.0	1.0	2.0	3.9	4.5
p,p'-DDE	4.7	6.2	8.2	7.7	17.7	16.6
o,p'-DDD	0.3	0.4	0.4	5.2	2.5	1.8
p,p'-DDD	0.6	0.9	1.7	8.5	5.7	7.9
o,p'-DDT	0.9	0.8	0.9	34.1	8.3	8.7
p,p'-DDT	3.5	4.6	8.6	12.6	19.0	17.4
Sum of DDT	10.6	14.0	20.8	70.1	57.1	57.0
PeCB	33.0	28.6	28.4	16.6	8.9	8.7
HCB	22.7	23.4	21.8	20.0	9.8	9.0

Table E 7: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the urban sampling site in Ethiopia, Asela

ETHIOPIA - Asela						
Concentration ng/filter						
Sample code	ETH 01 A 01	ETH 01 A 02	ETH 01 A 03	ETH 01 A 04	ETH 01 A 05	ETH 01 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-31.3.2008	31.3.-2.5.2008	2.5.-5.6.2008	5.6.-4.7.2008
PCB 28	0.6	<LOQ	0.3	0.8	0.5	0.4
PCB 52	0.2	0.5	0.4	0.8	0.5	0.8
PCB 101	<LOQ	<LOQ	<LOQ	0.2	<LOQ	<LOQ
PCB 118	<LOQ	<LOQ	<LOQ	0.4	<LOQ	<LOQ
PCB 153	<LOQ	0.2	0.2	0.2	0.7	0.7
PCB 138	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 180	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of PCB	0.8	0.7	0.9	2.3	1.6	1.9
alpha-HCH	1.4	1.1	<LOQ	<LOQ	<LOQ	<LOQ
beta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
gamma-HCH	21.9	6.8	0.9	12.8	14.4	38.2
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	23.4	7.8	0.9	12.8	14.4	38.2
o,p'-DDE	2.0	2.7	3.2	3.9	3.9	3.3
p,p'-DDE	12.5	15.2	17.5	18.9	23.0	24.4
o,p'-DDD	2.1	2.0	4.3	3.5	4.0	5.9
p,p'-DDD	5.2	7.0	11.5	7.9	8.7	12.9
o,p'-DDT	11.1	17.8	19.2	17.6	24.3	37.1
p,p'-DDT	28.5	50.4	62.9	56.1	49.3	68.7
Sum of DDT	61.5	95.1	118.6	108.0	113.1	152.4
PeCB	1.1	1.5	1.1	0.7	1.1	<LOQ
HCB	4.1	3.4	2.8	2.9	2.8	3.2

Table E 8: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the sampling site Ghana – Kwabenya

GHANA - Kwabenya						
	Concentration ng/filter					
Sample code	GHA 01 A 01	GHA 01 A 02	GHA 01 A 03	GHA 01 A 04	GHA 01 A 05	GHA 01 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-31.3.2008	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008
PCB 28	1.0	1.1	1.1	1.0	0.7	0.5
PCB 52	2.7	1.8	1.6	3.7	2.3	2.7
PCB 101	2.5	1.9	1.3	2.1	1.9	0.9
PCB 118	1.7	1.5	1.3	2.0	2.1	1.4
PCB 153	1.9	1.8	1.5	2.0	1.8	1.8
PCB 138	1.1	1.0	1.2	1.4	0.8	0.8
PCB 180	1.0	0.3	0.4	0.4	0.2	0.2
Sum of PCB	12.0	9.5	8.4	12.6	9.9	8.2
alpha-HCH	1.4	<LOQ	2.5	1.6	2.9	4.5
beta-HCH	<LOQ	<LOQ	2.3	3.3	1.9	<LOQ
gamma-HCH	7.3	6.0	4.3	4.0	2.1	3.3
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	8.7	6.0	9.1	8.9	6.9	7.7
o,p'-DDE	<LOQ	0.3	<LOQ	<LOQ	<LOQ	0.5
p,p'-DDE	2.4	2.6	2.4	2.7	2.4	2.0
o,p'-DDD	0.3	0.4	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDD	0.4	1.1	0.4	0.4	1.0	0.7
o,p'-DDT	0.7	0.3	<LOQ	0.4	0.4	0.7
p,p'-DDT	0.7	1.3	1.4	1.2	1.3	1.8
Sum of DDT	4.4	6.1	4.2	4.7	5.1	5.7
PeCB	1.5	0.9	1.0	0.4	0.3	0.4
HCB	2.6	1.9	1.7	1.9	2.2	1.8

Table E 9: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the sampling site Ghana – East Legon

GHANA - East Legon						
	Concentration ng/filter					
Sample code	GHA 02 A 01	MAL 02 A 02	MAL 02 A 03	MAL 02 A 04	MAL 02 A 05	MAL 02 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-31.3.2008	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008
PCB 28	3.8	1.1	1.7	1.0	1.0	1.0
PCB 52	2.3	2.7	3.3	1.7	2.1	1.2
PCB 101	1.7	3.9	3.5	1.0	1.0	0.4
PCB 118	1.7	2.8	4.2	1.2	1.8	1.1
PCB 153	2.1	4.0	3.6	1.4	1.0	1.3
PCB 138	1.8	2.8	2.7	1.4	1.2	1.2
PCB 180	0.7	1.7	1.2	0.4	0.7	0.6
Sum of PCB	14.1	18.9	20.3	8.1	8.7	6.9
alpha-HCH	<LOQ	<LOQ	0.6	5.4	8.1	2.6
beta-HCH	<LOQ	<LOQ	<LOQ	1.7	3.2	2.0
gamma-HCH	3.0	7.0	6.4	3.6	6.3	3.8
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	3.0	7.0	7.0	10.7	17.6	8.3
o,p'-DDE	0.2	0.3	0.5	0.4	0.6	1.2
p,p'-DDE	4.1	5.5	6.8	4.2	3.4	4.0
o,p'-DDD	0.6	0.7	0.8	0.7	0.7	0.5
p,p'-DDD	0.6	1.9	2.7	1.2	1.2	0.7
o,p'-DDT	0.3	1.9	3.2	1.4	0.7	1.4
p,p'-DDT	2.1	4.4	6.5	3.5	1.9	1.7
Sum of DDT	7.9	14.6	20.6	11.5	8.4	9.5
PeCB	1.1	1.1	1.2	<LOQ	0.5	0.5
HCB	2.8	1.3	2.2	1.4	1.2	1.6

Table E 10: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the background sampling site Kenya – Mt. Kenya

KENYA - Mt. Kenya						
Concentration ng/filter						
Sample code	KEN 01 A 01	KEN 01 A 02	KEN 01 A 03	KEN 01 A 02	KEN 01 A 03	KEN 01 A 04
Collection date	4.3.-1.4.2008	13.5.-19.6.2008	19.6.-8.7.2008	8.7.-6.8.2008		
PCB 28		<LOQ	0.4	0.5		0.4
PCB 52		<LOQ	0.2	0.6		<LOQ
PCB 101		<LOQ	<LOQ	<LOQ		<LOQ
PCB 118		<LOQ	<LOQ	<LOQ		<LOQ
PCB 153		<LOQ	<LOQ	0.6		0.3
PCB 138		<LOQ	<LOQ	<LOQ		<LOQ
PCB 180		<LOQ	<LOQ	0.4		0.4
Sum of PCB		<LOQ	0.6	2.1		1.1
alpha-HCH		2.6	2.0	9.8		1.5
beta-HCH		<LOQ	2.1	3.7		0.5
gamma-HCH		3.9	4.0	6.2		2.7
delta-HCH		<LOQ	<LOQ	<LOQ		<LOQ
Sum of HCH		6.5	8.1	19.6		4.8
o,p'-DDE		<LOQ	<LOQ	<LOQ		<LOQ
p,p'-DDE		0.6	0.4	1.3		0.4
o,p'-DDD		<LOQ	<LOQ	<LOQ		<LOQ
p,p'-DDD		<LOQ	<LOQ	<LOQ		0.3
o,p'-DDT		<LOQ	<LOQ	<LOQ		<LOQ
p,p'-DDT		0.3	0.9	0.5		1.4
Sum of DDT		0.9	1.3	1.8		2.1
PeCB		1.0	0.5	0.6		0.4
HCB		2.7	2.3	6.0		1.6

Table E 11: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the urban sampling site Kenya – Kabete

KENYA - Kabete						
Concentration ng/filter						
Sample code	KEN 02 A 01	KEN 02 A 02	KEN 02 A 01	KEN 02 A 04	KEN 02 A 05	KEN 02 A 06
Collection date	4.2.-4.3.2008	4.3.-1.4.2008	1.4.-6.5.2008	6.5.-6.6.2008	6.6.-3.7.2008	3.7.-8.8.2008
PCB 28	0.5	0.8	0.8	0.3	0.3	0.3
PCB 52	0.3	0.3	1.3	0.4	0.3	<LOQ
PCB 101	<LOQ	<LOQ	<LOQ	0.5	0.2	0.3
PCB 118	0.3	<LOQ	0.2	0.3	0.3	0.2
PCB 153	0.3	0.4	0.2	0.2	0.6	0.2
PCB 138	<LOQ	<LOQ	<LOQ	0.5	0.3	0.2
PCB 180	<LOQ	<LOQ	<LOQ	0.7	<LOQ	0.8
Sum of PCB	1.3	1.5	2.5	2.8	1.9	2.1
alpha-HCH	1.2	1.4	0.9	1.1	2.3	1.3
beta-HCH	<LOQ	7.3	<LOQ	1.4	3.3	1.4
gamma-HCH	6.8	22.1	3.5	2.5	2.2	3.3
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	8.0	30.8	4.4	5.1	7.8	6.1
o,p'-DDE	0.5	0.2	0.7	0.3	0.3	0.4
p,p'-DDE	3.9	6.1	4.7	2.7	2.6	0.3
o,p'-DDD	0.3	<LOQ	<LOQ	0.4	<LOQ	0.2
p,p'-DDD	0.3	<LOQ	0.3	<LOQ	0.3	0.5
o,p'-DDT	1.2	1.6	1.6	0.2	0.4	1.1
p,p'-DDT	3.2	4.5	3.9	0.8	1.3	1.2
Sum of DDT	9.3	12.4	11.1	4.4	4.8	3.5
PeCB	1.2	0.9	0.4	<LOQ	0.2	0.2
HCB	2.3	1.7	1.8	2.3	0.4	0.8

Table E 12: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the sampling site Kenya – Kitengela

KENYA - Kitengela						
	Concentration ng/filter					
Sample code	KEN 03 A 01	KEN 03 A 02	KEN 03 A 03	KEN 03 A 04	KEN 03 A 05	KEN 03 A 06
Collection date	4.2.-4.3.2008	5.3.-1.4.2008		7.5.-6.6.2008	6.6.-4.7.2008	4.7.-11.8.2008
PCB 28	2.1	2.5		1.3	0.9	1.4
PCB 52	2.1	1.4		0.7	1.0	1.7
PCB 101	0.4	0.2		0.2	0.6	0.4
PCB 118	0.2	0.9		0.2	1.2	0.4
PCB 153	0.4	0.6		0.4	0.8	0.4
PCB 138	<LOQ	<LOQ		<LOQ	0.3	<LOQ
PCB 180	<LOQ	<LOQ		<LOQ	0.2	<LOQ
Sum of PCB	5.2	5.6		2.8	5.0	4.3
alpha-HCH	1 788.2	1 402.5		584.5	454.6	553.2
beta-HCH	187.2	233.7		154.1	130.7	213.5
gamma-HCH	1 289.6	1 235.8		496.4	507.8	527.7
delta-HCH	6 042.4	3 656.6		1 216.2	846.0	1 064.2
Sum of HCH	9 307.5	6 528.6		2 451.3	1 939.1	2 358.6
o,p'-DDE	383.5	681.6		125.4	116.3	152.6
p,p'-DDE	1 327.7	2 653.7		931.3	925.0	1 102.7
o,p'-DDD	60.0	117.5		41.4	40.2	19.1
p,p'-DDD	72.4	154.1		56.6	51.4	79.1
o,p'-DDT	941.2	1 837.1		420.7	351.2	509.9
p,p'-DDT	1 319.6	3 525.8		693.0	485.8	721.0
Sum of DDT	4 104.4	8 969.9		2 268.4	1 969.8	2 584.4
PeCB	6.6	13.8		9.9	13.3	11.4
HCB	3.7	5.4		6.0	5.1	5.6

Table E 13: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the sampling site Kenya – Industrial area

KENYA - Industrial site						
	Concentration ng/filter					
Sample code	KEN 04 A 01	KEN 04 A 02	KEN 04 A 03	KEN 04 A 04	KEN 04 A 05	KEN 04 A 06
Collection date	3.2.-4.3.2008	4.3.-1.4.2008	1.4.-6.5.2008	6.5.-6.6.2008	6.6.-4.7.2008	4.7.-8.8.2008
PCB 28	3.6	48.1	12.7	6.4	5.0	8.0
PCB 52	3.1	14.7	7.0	11.0	6.9	8.5
PCB 101	1.5	2.8	3.5	15.3	5.7	3.0
PCB 118	1.3	1.7	2.8	12.6	9.9	4.6
PCB 153	1.1	2.0	1.9	8.3	4.0	1.9
PCB 138	0.8	1.5	1.6	6.9	7.6	1.1
PCB 180	0.2	0.5	0.5	2.4	3.0	0.6
Sum of PCB	11.7	71.3	29.9	62.8	42.1	27.8
alpha-HCH	3.5	<LOQ	2.2	0.4	0.3	<LOQ
beta-HCH	<LOQ	<LOQ	1.1	<LOQ	0.4	0.2
gamma-HCH	11.9	18.5	10.8	1.8	1.1	1.4
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	15.5	18.5	14.0	2.2	1.8	1.5
o,p'-DDE	1.8	2.1	1.9	0.3	0.2	0.2
p,p'-DDE	43.5	69.0	54.4	16.6	8.9	19.7
o,p'-DDD	<LOQ	1.1	1.2	0.4	0.5	<LOQ
p,p'-DDD	3.0	3.0	2.0	1.0	0.7	0.7
o,p'-DDT	4.5	5.2	5.7	0.6	0.4	0.2
p,p'-DDT	15.3	18.3	16.6	8.7	9.0	8.1
Sum of DDT	68.2	98.6	81.7	27.6	19.8	28.9
PeCB	1.9	2.3	2.3	1.5	3.2	1.7
HCB	3.8	4.5	4.4	3.6	4.6	4.1

Table E 14: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the sampling site Kenya – Dandora

KENYA - Dandora						
	Concentration ng/filter					
Sample code	KEN 05 A 01	KEN 05 A 02	KEN 05 A 03	KEN 05 A 04	KEN 05 A 05	KEN 05 A 06
Collection date	5.2.-4.3.2008	4.3.-1.4.2008	1.4.-6.5.2008	6.5.-6.6.2008	6.6.-4.7.2008	4.7.-8.8.2008
PCB 28	8.4	9.2	9.4	10.6	14.5	9.4
PCB 52	7.7	10.7	7.7	6.7	2.7	4.8
PCB 101	3.8	5.7	1.8	1.2	2.9	3.0
PCB 118	2.2	3.9	1.6	1.5	1.5	1.9
PCB 153	2.3	2.5	0.9	1.0	0.4	1.9
PCB 138	1.7	2.4	0.6	1.0	1.3	2.1
PCB 180	0.9	0.4	0.5	0.3	1.8	1.3
Sum of PCB	27.0	34.7	22.4	22.2	25.1	24.4
alpha-HCH	2.4	<LOQ	<LOQ	<LOQ	2.6	1.6
beta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
gamma-HCH	20.2	17.1	23.3	1.2	6.9	7.0
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	22.6	17.1	23.3	1.2	9.5	8.6
o,p'-DDE	1.3	1.9	1.7	0.8	0.9	1.1
p,p'-DDE	8.4	10.2	5.1	5.6	3.6	5.1
o,p'-DDD	4.7	3.9	2.4	1.2	1.8	1.5
p,p'-DDD	10.4	8.0	4.0	1.4	2.1	2.9
o,p'-DDT	3.5	3.2	2.5	2.4	0.7	1.8
p,p'-DDT	11.0	12.8	4.9	3.3	10.4	3.2
Sum of DDT	39.3	40.1	20.6	14.7	19.5	15.5
PeCB	6.7	3.1	2.6	10.9	13.0	5.4
HCB	4.5	7.3	4.6	9.8	12.4	8.5

Table E 15: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the sampling site Mali – Tomboucouteu

MALI - Tomboucouteu						
	Concentration ng/filter					
Sample code	MAL 01 A 01	MAL 01 A 02	MAL 01 A 03	MAL 01 A 04	MAL 01 A 05	MAL 01 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-12.4.2008	12.4.-11.5.2008	11.5.-8.6.2008	8.6.-5.7.2008
PCB 28	<LOQ	<LOQ	<LOQ	0.5	0.2	0.3
PCB 52	<LOQ	<LOQ	0.2	1.3	<LOQ	<LOQ
PCB 101	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 118	<LOQ	<LOQ	<LOQ	0.6	<LOQ	<LOQ
PCB 153	<LOQ	<LOQ	<LOQ	0.4	0.4	<LOQ
PCB 138	<LOQ	<LOQ	<LOQ	0.2	<LOQ	<LOQ
PCB 180	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of PCB	<LOQ	<LOQ	0.2	3.0	0.6	0.3
alpha-HCH	3.3	<LOQ	0.5	2.0	1.2	2.4
beta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
gamma-HCH	1.9	1.6	1.8	<LOQ	3.0	4.8
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	5.2	1.6	2.3	2.0	4.2	7.2
o,p'-DDE	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDE	0.3	<LOQ	0.2	1.4	1.1	1.9
o,p'-DDD	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDD	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
o,p'-DDT	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDT	0.7	<LOQ	0.3	1.2	0.6	0.5
Sum of DDT	1.0	<LOQ	0.5	2.6	1.7	2.4
PeCB	1.5	0.9	0.9	<LOQ	<LOQ	<LOQ
HCB	4.0	2.0	2.0	3.3	2.2	3.2

Table E 16: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the sampling site Mali – Bamako centre

MALI - Bamako centre						
	Concentration ng/filter					
Sample code	MAL 02 A 01	MAL 02 A 02	MAL 02 A 03	MAL 02 A 04	MAL 02 A 05	MAL 02 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-12.4.2008	12.4.-10.5.2008	10.5.-8.6.2008	8.6.-5.7.2008
PCB 28	2.8	3.5	2.9	3.7	3.3	2.9
PCB 52	2.4	2.4	2.6	4.5	3.3	1.7
PCB 101	1.8	2.3	1.9	4.9	3.9	2.3
PCB 118	1.1	1.4	2.2	3.5	3.8	1.2
PCB 153	2.8	3.9	3.7	4.7	3.9	6.2
PCB 138	2.4	2.1	2.7	2.7	2.8	3.5
PCB 180	1.6	1.9	2.2	2.1	1.6	2.7
Sum of PCB	14.9	17.5	18.2	26.1	22.6	20.5
alpha-HCH	2.9	3.1	1.4	10.2	2.3	0.9
beta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
gamma-HCH	3.8	13.5	17.2	34.7	34.8	8.0
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	6.7	16.6	18.5	44.9	37.1	8.9
o,p'-DDE	4.6	6.9	7.9	14.1	15.9	6.0
p,p'-DDE	35.3	45.1	56.3	88.1	91.8	40.6
o,p'-DDD	5.3	6.0	8.3	10.4	9.6	3.5
p,p'-DDD	5.7	8.1	8.9	10.0	10.3	4.8
o,p'-DDT	5.0	7.7	8.9	13.0	12.4	9.5
p,p'-DDT	12.7	17.9	20.8	23.9	23.7	19.7
Sum of DDT	68.6	91.7	111.1	159.4	163.8	84.1
PeCB	3.3	1.8	1.4	0.4	0.4	0.3
HCB	4.7	2.8	1.7	2.6	1.4	2.5

Table E 17: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the sampling site Mali - Bamako international airport

MALI - Bamako airport						
	Concentration ng/filter					
Sample code	MAL 03 A 01	MAL 03 A 02	MAL 03 A 03	MAL 03 A 04	MAL 03 A 05	MAL 03 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-12.4.2008	12.4.-10.5.2008	10.5.-8.6.2008	8.6.-5.7.2008
PCB 28	0.3	0.4	0.5	3.1	1.4	1.3
PCB 52	0.3	0.8	0.7	5.8	1.6	1.5
PCB 101	<LOQ	0.5	0.8	4.5	1.6	1.3
PCB 118	0.3	0.5	0.2	3.5	0.6	0.6
PCB 153	1.4	2.0	2.4	4.0	4.5	6.7
PCB 138	0.8	1.2	1.1	2.8	1.8	3.4
PCB 180	0.2	0.7	0.6	1.9	1.6	2.7
Sum of PCB	3.4	6.1	6.3	25.6	13.1	17.4
alpha-HCH	1.3	2.1	<LOQ	1.9	1.7	3.7
beta-HCH	<LOQ	<LOQ	<LOQ	2.3	10.5	3.1
gamma-HCH	6.3	5.6	4.6	25.1	12.2	3.6
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	7.5	7.6	4.6	29.3	24.4	10.4
o,p'-DDE	<LOQ	<LOQ	0.6	16.2	1.8	3.5
p,p'-DDE	1.2	6.6	4.6	83.8	11.5	22.8
o,p'-DDD	0.4	0.9	0.6	7.4	0.3	2.5
p,p'-DDD	0.5	2.2	0.9	7.3	0.2	3.2
o,p'-DDT	0.3	1.6	0.8	7.8	<LOQ	3.8
p,p'-DDT	0.4	4.2	2.0	16.9	1.2	7.8
Sum of DDT	2.7	15.5	9.6	139.2	15.1	43.5
PeCB	0.8	1.2	0.6	0.5	<LOQ	<LOQ
HCB	2.9	1.9	1.2	2.3	2.2	2.2

Table E 18: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the agricultural sampling site Mali – Koutiala

MALI - Koutiala						
	Concentration ng/filter					
Sample code	MAL 04 A 01	MAL 04 A 02	MAL 04 A 03	MAL 04 A 04	MAL 04 A 05	MAL 04 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-12.4.2008	12.4.-10.5.2008	10.5.-7.6.2008	7.6.-5.7.2008
PCB 28	<LOQ	0.5	0.1	0.9	0.6	0.7
PCB 52	<LOQ	0.9	0.2	0.8	0.8	1.0
PCB 101	<LOQ	<LOQ	<LOQ	<LOQ	0.5	<LOQ
PCB 118	<LOQ	<LOQ	0.3	0.3	0.4	0.3
PCB 153	1.0	1.2	1.2	0.6	1.3	1.2
PCB 138	0.3	0.5	0.5	0.7	0.9	1.0
PCB 180	0.3	0.3	0.2	0.8	0.6	0.2
Sum of PCB	1.6	3.4	2.6	4.1	5.0	4.5
alpha-HCH	<LOQ	<LOQ	1.6	<LOQ	1.5	6.2
beta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	2.9
gamma-HCH	3.1	12.1	9.9	8.4	6.6	8.5
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	3.1	12.1	11.5	8.4	8.1	17.6
o,p'-DDE	2.8	1.7	1.8	2.6	3.4	6.7
p,p'-DDE	10.9	11.2	10.8	13.0	26.2	44.3
o,p'-DDD	1.4	1.6	1.9	2.6	1.6	3.6
p,p'-DDD	1.4	0.8	3.1	2.8	2.4	3.7
o,p'-DDT	1.7	2.5	3.0	1.6	3.3	4.9
p,p'-DDT	5.3	5.6	8.2	6.0	7.9	11.0
Sum of DDT	23.6	23.4	28.9	28.7	44.9	74.1
PeCB	1.5	1.7	0.9	<LOQ	0.2	0.3
HCB	2.6	2.0	1.3	1.8	1.6	2.8

Table E 19: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the agricultural sampling site Mali – Niono

MALI - Niono						
	Concentration ng/filter					
Sample code	MAL 05 A 01	MAL 05 A 02	MAL 05 A 03	MAL 05 A 04	MAL 05 A 05	MAL 05 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-12.4.2008	12.4.-10.5.2008	10.5.-8.6.2008	8.6.-5.7.2008
PCB 28	0.2	0.4	<LOQ	0.8	0.4	0.7
PCB 52	0.4	0.3	0.2	<LOQ	0.2	0.6
PCB 101	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 118	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 153	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.7
PCB 138	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.5
PCB 180	<LOQ	<LOQ	0.1	<LOQ	<LOQ	<LOQ
Sum of PCB	0.6	0.7	0.4	0.8	0.6	2.5
alpha-HCH	0.7	<LOQ	2.5	<LOQ	1.3	<LOQ
beta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
gamma-HCH	3.7	2.7	1.8	3.3	2.5	6.9
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	4.4	2.7	4.3	3.3	3.8	6.9
o,p'-DDE	0.3	<LOQ	0.1	0.9	1.5	2.7
p,p'-DDE	2.3	4.8	3.5	7.5	8.9	17.0
o,p'-DDD	0.2	<LOQ	<LOQ	<LOQ	<LOQ	0.6
p,p'-DDD	0.2	<LOQ	<LOQ	0.5	0.9	1.5
o,p'-DDT	0.4	<LOQ	0.3	0.4	0.6	0.6
p,p'-DDT	0.4	0.5	0.5	4.4	0.9	2.0
Sum of DDT	3.7	5.3	4.5	13.7	12.8	24.4
PeCB	1.1	1.8	0.7	<LOQ	<LOQ	<LOQ
HCB	3.2	2.0	1.2	0.9	1.1	2.1

Table E 20: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the background sampling site in Mauritius

MAURITIUS - Reduit						
	Concentration ng/filter					
Sample code	MAU01A01	MAU01A02	MAU01A03	MAU 01 A 04	MAU 01 A 05	MAU 01 A 06
Collection date	7.1.-8.2.08	8.2.-3.3.08	3.3.-31.3.08	31.3.-28.4.2008	28.4.-10.6.2008	10.6.-24.6.2008
PCB 28	0.3	0.3	0.3	0.5	0.4	0.5
PCB 52	0.2	0.8	0.2	0.3	0.6	1.0
PCB 101	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 118	0.2	<LOQ	<LOQ	0.2	<LOQ	<LOQ
PCB 153	0.2	0.2	<LOQ	0.4	<LOQ	0.5
PCB 138	<LOQ	<LOQ	<LOQ	<LOQ	0.3	1.2
PCB 180	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of PCB	0.9	1.3	0.6	1.4	1.3	3.2
alpha-HCH	0.5	0.7	0.3	<LOQ	<LOQ	<LOQ
beta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	3.9
gamma-HCH	1.6	3.3	3.8	8.9	5.2	11.5
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	2.1	4.0	4.1	8.9	5.2	15.4
o,p'-DDE	0.3	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDE	4.0	2.8	3.4	6.0	2.7	3.7
o,p'-DDD	0.6	<LOQ	0.3	1.5	1.6	<LOQ
p,p'-DDD	0.3	<LOQ	<LOQ	3.1	0.7	1.4
o,p'-DDT	0.4	<LOQ	0.3	3.6	1.4	0.5
p,p'-DDT	1.5	0.6	1.1	7.1	2.2	4.2
Sum of DDT	7.1	3.4	5.1	21.2	8.5	9.8
PeCB	0.4	0.7	0.9	0.3	0.1	<LOQ
HCB	1.2	<LOQ	2.2	1.8	1.2	3.2

Table E 21: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the agricultural sampling site in Nigeria, Sheda

NIGERIA - Sheda						
	Concentration ng/filter					
Sample code	NIG 01 A 01	NIG 01 A 02	NIG 01 A 03	NIG 01 A 04	NIG 01 A 05	NIG 01 A 06
Collection date	7.1.-4.2.2008	7.2.-3.3.2008	3.3.-31.3.2008	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008
PCB 28	0.2	0.8	0.5	1.3	<LOQ	0.4
PCB 52	0.6	0.6	0.4	3.3	0.4	0.4
PCB 101	<LOQ	0.3	<LOQ	2.0	0.6	<LOQ
PCB 118	<LOQ	<LOQ	<LOQ	2.3	<LOQ	<LOQ
PCB 153	0.3	0.7	<LOQ	1.9	<LOQ	<LOQ
PCB 138	<LOQ	0.4	<LOQ	1.3	<LOQ	0.3
PCB 180	<LOQ	0.3	<LOQ	0.8	<LOQ	<LOQ
Sum of PCB	1.1	3.2	0.9	12.9	1.0	1.1
alpha-HCH	1.1	1.7	1.9	0.6	0.7	<LOQ
beta-HCH	<LOQ	<LOQ	<LOQ	2.3	2.3	<LOQ
gamma-HCH	8.7	5.8	1.5	6.5	4.3	3.3
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	9.9	7.4	3.4	9.3	7.2	3.3
o,p'-DDE	<LOQ	0.3	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDE	0.7	2.4	1.5	5.6	2.1	0.9
o,p'-DDD	<LOQ	0.6	<LOQ	<LOQ	0.3	<LOQ
p,p'-DDD	<LOQ	1.1	0.2	2.7	0.6	0.4
o,p'-DDT	<LOQ	2.0	<LOQ	1.7	0.6	<LOQ
p,p'-DDT	0.6	3.7	0.4	4.7	3.2	0.8
Sum of DDT	1.3	10.0	2.1	14.7	6.8	2.1
PeCB	1.0	1.5	1.0	0.7	<LOQ	<LOQ
HCB	1.6	1.9	1.2	2.2	2.0	1.7

Table E 22: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the urban sampling site in Senegal, Dakar

SENEGAL - Dakar						
	Concentration ng/filter					
Sample code	SEN 01 A 01	SEN 01 A 02	SEN 01 A 03	SEN 01 A 04	SEN 01 A 05	SEN 01 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-31.3.2008		28.4.-26.5.2008	26.5.-23.6.2008
PCB 28	7.4	12.7	10.8		8.6	4.5
PCB 52	8.9	15.0	13.4		14.7	6.5
PCB 101	11.6	12.9	14.0		<LOQ	6.8
PCB 118	7.2	9.2	9.4		11.8	5.3
PCB 153	14.0	22.4	27.2		39.8	13.1
PCB 138	9.4	18.0	19.0		29.2	9.6
PCB 180	7.1	13.4	16.7		28.4	8.5
Sum of PCB	65.6	103.6	110.5		132.4	54.3
alpha-HCH	<LOQ	0.6	0.6		0.7	1.8
beta-HCH	<LOQ	<LOQ	<LOQ		<LOQ	3.3
gamma-HCH	25.5	9.1	20.4		28.3	9.5
delta-HCH	<LOQ	<LOQ	<LOQ		<LOQ	<LOQ
Sum of HCH	25.5	9.7	21.0		28.9	14.6
o,p'-DDE	4.4	10.2	17.7		33.7	26.2
p,p'-DDE	42.5	83.9	139.3		227.1	228.0
o,p'-DDD	2.2	5.9	6.7		14.6	13.1
p,p'-DDD	8.2	13.7	18.7		35.4	26.6
o,p'-DDT	10.5	24.7	43.7		118.8	79.1
p,p'-DDT	25.0	75.6	133.1		367.4	218.9
Sum of DDT	92.7	214.1	359.2		796.9	591.8
PeCB	1.4	0.9	0.9		<LOQ	0.2
HCB	3.4	2.8	3.2		2.3	2.4

Table E 23: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the background sampling site South Africa – Molopo Nature reservation

SOUTH AFRICA - Molopo Nature reservation							
	Concentration ng/filter						
Sample code	SAF 01 A 01	SAF 01 A 02	SAF 01 A 03	SAF 01 A 04	SAF 01 A 05	SAF 01 A 06	SAF 01 A 07
Collection date	15.1.-12.2.2008	12.2.-11.3.2008	12.3.-15.4.2008	15.4.-12.5.2008	12.5.-6.6.2008	6.6.-3.7.2008	3.7.-31.7.2008
PCB 28	0.3	<LOQ	<LOQ	0.2	0.3	<LOQ	1.0
PCB 52	0.4	0.4	0.2	<LOQ	0.3	0.4	1.9
PCB 101	<LOQ	<LOQ	<LOQ	0.2	0.2	<LOQ	<LOQ
PCB 118	<LOQ	0.2	<LOQ	<LOQ	<LOQ	<LOQ	0.7
PCB 153	<LOQ	0.3	<LOQ	<LOQ	<LOQ	0.2	1.0
PCB 138	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.6
PCB 180	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.7
Sum of PCB	0.7	0.9	0.2	0.4	0.8	0.6	6.0
alpha-HCH	0.8	1.7	1.0	0.6	0.8	0.4	3.2
beta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
gamma-HCH	6.4	7.0	1.5	1.2	3.0	1.6	2.4
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	7.2	8.7	2.5	1.8	3.8	2.0	5.6
o,p'-DDE	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.3	<LOQ
p,p'-DDE	0.4	0.4	0.6	0.5	0.2	0.4	0.9
o,p'-DDD	<LOQ	<LOQ	0.2	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDD	0.8	<LOQ	<LOQ	0.6	0.2	0.2	<LOQ
o,p'-DDT	<LOQ	0.4	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDT	1.5	1.0	<LOQ	<LOQ	0.5	0.5	0.6
Sum of DDT	2.8	1.8	0.7	1.0	0.9	1.3	1.5
PeCB	0.9	0.8	0.5	0.2	0.2	0.2	<LOQ
HCB	1.3	1.3	1.3	0.3	0.6	1.0	1.1

Table E 24: Temporal variations of PCB and OCP concentrations in the ambient air (ng filt7r⁻¹) at the background sampling site South Africa – Barberspan

SOUTH AFRICA - Barberspan							
	Concentration ng/filter						
Sample code	SAF 02 A 01	SAF 02 A 02	SAF 02 A 03	SAF 02 A 04	SAF 02 A 05	SAF 02 A 06	SAF 02 A 07
Collection date	15.1.-12.2.2008	12.2.-10.3.2008	10.3.-13.4.2008	13.4.-12.5.2008	12.5.-6.6.2008	6.6.-3.7.2008	3.7.-31.7.2008
PCB 28	0.2	<LOQ	<LOQ	<LOQ	0.2	0.2	0.4
PCB 52	0.4	0.3	0.5	0.2	<LOQ	0.3	0.3
PCB 101	<LOQ	<LOQ	<LOQ	0.5	0.3	0.2	0.2
PCB 118	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.2
PCB 153	<LOQ	<LOQ	<LOQ	<LOQ	0.4	0.4	<LOQ
PCB 138	<LOQ	<LOQ	<LOQ	0.3	0.4	0.3	<LOQ
PCB 180	<LOQ	<LOQ	<LOQ	0.5	<LOQ	0.3	<LOQ
Sum of PCB	0.7	0.3	0.5	1.4	1.3	1.8	1.1
alpha-HCH	1.2	0.8	0.8	0.6	0.7	1.2	1.4
beta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
gamma-HCH	10.3	11.4	9.3	4.1	3.1	2.4	0.7
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	11.5	12.1	10.1	4.7	3.8	3.6	2.1
o,p'-DDE	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDE	1.5	1.6	1.1	0.9	0.7	1.0	0.4
o,p'-DDD	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDD	1.3	0.8	0.2	0.2	0.4	0.2	0.2
o,p'-DDT	0.3	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDT	2.0	2.8	0.4	0.5	0.9	0.4	<LOQ
Sum of DDT	5.1	5.2	1.8	1.6	2.1	1.7	0.6
PeCB	0.8	0.9	0.8	<LOQ	0.3	0.5	<LOQ
HCB	1.7	2.0	1.8	0.6	1.0	0.6	<LOQ

Table E 25: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the industrial sampling site South Africa – Vanderbijl Park

SOUTH AFRICA - Vanderbijl Park							
	Concentration ng/filter						
Sample code	SAF 03 A 01	SAF 03 A 02	SAF 03 A 03	SAF 03 A 04	SAF 03 A 05	SAF 03 A 06	SAF 03 A 07
Collection date	15.1.-12.2.2008	12.2.-10.3.2008	10.3.-14.4.2008	14.4.-12.5.2008	12.5.-6.6.2008	6.6.-3.7.2008	3.7.-31.7.2008
PCB 28	1.5	1.6	1.4	0.2	0.3	1.0	0.5
PCB 52	0.5	1.4	0.8	0.3	0.5	2.1	0.5
PCB 101	0.5	<LOQ	0.4	<LOQ	0.4	0.3	0.5
PCB 118	<LOQ	0.3	0.3	<LOQ	<LOQ	<LOQ	0.5
PCB 153	0.2	0.3	0.4	<LOQ	0.6	0.3	0.2
PCB 138	0.2	<LOQ	<LOQ	<LOQ	<LOQ	0.6	0.5
PCB 180	<LOQ	<LOQ	0.2	<LOQ	<LOQ	0.2	0.4
Sum of PCB	2.9	3.7	3.5	0.5	1.8	4.4	3.1
alpha-HCH	2.7	3.8	2.4	1.6	3.2	2.7	3.4
beta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
gamma-HCH	25.7	31.9	41.1	7.6	13.0	18.5	5.1
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	28.3	35.7	43.5	9.3	16.3	21.2	8.5
o,p'-DDE	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDE	3.2	1.6	1.3	0.7	1.7	1.2	0.8
o,p'-DDD	0.2	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.3
p,p'-DDD	1.3	1.6	0.2	<LOQ	<LOQ	<LOQ	0.4
o,p'-DDT	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.7
p,p'-DDT	1.5	2.7	0.6	0.3	0.4	0.8	0.7
Sum of DDT	6.3	5.9	2.1	1.1	2.1	1.9	2.9
PeCB	0.8	1.2	0.9	0.2	0.3	0.8	<LOQ
HCB	2.4	2.7	2.0	3.5	1.4	3.8	3.8

Table E 26: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the background sampling site in Sudan, Khartum

SUDAN - Khartum						
	Concentration ng/filter					
Sample code	SUD01A01	SUD01A02	SUD01A03	SUD 01 A 04	SUD 01 A 05	SUD 01 A 06
Collection date	7.1.-4.2.08	4.2.-3.3.08	3.3.-31.3.08	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008
PCB 28	1.9	3.0	2.5	2.8	2.4	2.4
PCB 52	3.0	3.9	4.6	6.9	5.1	4.7
PCB 101	2.0	2.0	2.0	4.5	4.2	6.0
PCB 118	2.5	2.2	1.8	3.2	2.6	3.8
PCB 153	1.9	1.8	2.0	6.2	4.9	9.1
PCB 138	1.4	1.1	1.3	4.8	3.5	6.6
PCB 180	1.1	1.0	0.8	4.0	3.0	6.6
Sum of PCB	13.8	15.0	15.2	32.5	25.8	39.2
alpha-HCH	2.2	0.9	0.5	3.8	3.4	1.8
beta-HCH	1.8	<LOQ	<LOQ	3.2	2.0	<LOQ
gamma-HCH	3.3	9.6	7.7	10.9	10.5	11.4
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	7.4	10.5	8.3	17.9	16.0	13.1
o,p'-DDE	6.3	6.9	5.6	10.5	8.4	10.3
p,p'-DDE	34.8	39.9	26.8	62.4	43.1	68.4
o,p'-DDD	1.1	2.4	0.7	4.1	3.3	4.9
p,p'-DDD	2.4	3.7	3.2	6.4	3.9	5.8
o,p'-DDT	2.3	1.7	2.9	5.7	2.7	7.2
p,p'-DDT	6.0	7.2	5.9	14.9	14.4	15.2
Sum of DDT	53.0	61.9	45.2	104.1	75.8	111.9
PeCB	2.4	1.6	1.5	1.2	1.6	1.0
HCB	7.3	2.8	1.8	3.3	2.8	2.5

Table E 27: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the sampling site in Togo, KoumaKonda

TOGO - Koumakonda						
	Concentration ng/filter					
Sample code	TOG 01 A 01	TOG 01 A 02	TOG 01 A 03	TOG 01 A 04	TOG 01 A 05	TOG 01 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-31.3.08	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008
PCB 28	<LOQ	0.2	0.3	2.4	0.7	0.9
PCB 52	<LOQ	1.6	<LOQ	0.9	1.0	0.6
PCB 101	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 118	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 153	<LOQ	0.2	0.3	0.9	<LOQ	0.4
PCB 138	<LOQ	<LOQ	<LOQ	0.4	<LOQ	0.5
PCB 180	<LOQ	<LOQ	<LOQ	0.4	<LOQ	<LOQ
Sum of PCB	<LOQ	2.0	0.6	5.1	1.8	2.3
alpha-HCH	2.4	1.6	1.2	2.7	1.9	5.0
beta-HCH	<LOQ	7.9	1.5	<LOQ	<LOQ	<LOQ
gamma-HCH	89.0	137.8	54.9	25.9	17.6	14.7
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	91.4	147.3	57.7	28.5	19.5	19.6
o,p'-DDE	<LOQ	<LOQ	<LOQ	0.3	0.3	1.3
p,p'-DDE	1.8	2.2	1.1	2.8	2.8	2.5
o,p'-DDD	<LOQ	<LOQ	<LOQ	<LOQ	0.4	<LOQ
p,p'-DDD	0.4	<LOQ	0.6	<LOQ	0.6	<LOQ
o,p'-DDT	0.3	<LOQ	<LOQ	<LOQ	1.0	<LOQ
p,p'-DDT	1.1	1.7	0.9	1.9	1.6	0.7
Sum of DDT	3.4	3.8	2.5	5.1	6.5	4.5
PeCB	1.9	1.7	1.3	0.8	0.3	1.0
HCB	1.7	1.9	1.6	2.3	2.2	2.2

Table E 28: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter-1) at the sampling site in Tunisia, Tunis

TUNISIA - Tunis						
	Concentration ng/filter					
Sample code	TUN 01 A 01	TUN 01 A 02	TUN 01 A 03	TUN 01 A 04	TUN 01 A 05	TUN 01 A 06
Collection date	4.2.-3.3.2008	3.3.-31.3.2008	3.3.-31.3.08	28.4.-26.5.2008	26.5.-23.6.2008	23.6.-21.7.2008
PCB 28	4.7	3.4	3.5	2.3	5.2	4.1
PCB 52	5.8	4.4	3.8	3.9	4.9	5.6
PCB 101	2.4	0.3	0.3	0.3	0.9	0.6
PCB 118	1.4	0.2	0.4	0.2	0.4	<LOQ
PCB 153	2.5	0.3	<LOQ	0.3	0.9	0.3
PCB 138	1.2	0.2	0.3	0.3	0.5	0.6
PCB 180	1.2	<LOQ	0.2	0.6	1.1	0.3
Sum of PCB	19.1	8.8	8.4	8.1	13.9	11.5
alpha-HCH	3 839.4	10.5	16.2	19.6	10.1	14.7
beta-HCH	631.2	1.4	2.8	<LOQ	5.6	6.8
gamma-HCH	6 773.0	4.8	17.4	19.1	8.3	10.0
delta-HCH	5 770.9	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	17 014.4	16.7	36.3	38.6	24.0	31.5
o,p'-DDE	<LOQ	<LOQ	<LOQ	0.2	<LOQ	<LOQ
p,p'-DDE	3.1	0.4	0.5	0.8	1.7	2.3
o,p'-DDD	0.3	0.2	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDD	0.5	0.2	0.2	0.4	1.1	0.6
o,p'-DDT	0.8	0.4	<LOQ	<LOQ	0.9	<LOQ
p,p'-DDT	0.9	0.6	0.4	0.8	0.5	1.1
Sum of DDT	5.6	1.8	1.2	2.3	4.3	4.0
PeCB	37.4	1.0	1.5	<LOQ	<LOQ	1.1
HCB	11.6	1.5	1.7	2.0	0.8	2.5

Table E 29: Temporal variations of PCB and OCP concentrations in the ambient air (ng filter⁻¹) at the sampling site in Zambia, Lusaka

ZAMBIA - Lusaka IA						
	Concentration ng/filter					
Sample code	ZAM 01 A 01	ZAM 01 A 02	ZAM 01 A 03	ZAM 01 A 04	ZAM 01 A 05	ZAM 01 A 06
Collection date	7.1.-4.2.2008	7.2.-3.3.2008	3.3.-31.3.08	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008
PCB 28	2.4	5.1	0.7	1.2	0.7	0.4
PCB 52	1.0	2.1	0.4	1.2	0.7	0.7
PCB 101	0.5	0.2	<LOQ	0.2	<LOQ	<LOQ
PCB 118	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 153	0.6	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 138	0.4	<LOQ	0.2	<LOQ	<LOQ	<LOQ
PCB 180	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of PCB	4.9	7.5	1.2	2.7	1.4	1.0
alpha-HCH	1.4	3.7	0.5	<LOQ	<LOQ	<LOQ
beta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
gamma-HCH	2.7	5.4	3.1	2.9	2.4	1.7
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	4.1	9.1	3.6	2.9	2.4	1.7
o,p'-DDE	1.1	1.4	<LOQ	<LOQ	0.4	<LOQ
p,p'-DDE	8.6	9.0	2.8	4.6	3.9	2.7
o,p'-DDD	1.8	1.1	0.5	<LOQ	0.4	0.5
p,p'-DDD	2.7	12.9	3.0	1.8	2.7	1.6
o,p'-DDT	19.4	19.6	0.4	4.0	5.3	2.7
p,p'-DDT	31.7	33.7	9.2	12.1	11.1	5.6
Sum of DDT	64.2	76.4	15.9	22.6	23.8	13.1
PeCB	0.7	0.7	0.7	0.5	0.9	0.6
HCB	1.7	1.6	0.8	2.0	3.4	3.0

Table E 30: Soil concentrations of PCBs and OCPs (ng g⁻¹) at the sampling sites in Africa

SOILS AFRICA 2008													
Koncentrace ng/g													
Sampling site	Ethiopia Asela	Ghana Kwabenya	Ghana East Legon	Kenya Mt.Kenya	Kenya Kabete	Kenya Ktengela	Kenya Industrial site	Kenya Dandora	Mali Tombuctu	Mali Bamako centre	Mali airport	Mali Koutiala	Mali Niono
Sample code Collection date	ETH 01	GHA 01	GHA 02	KEN 01 13.5.2008	KEN 02	KEN 03	KEN 04	KEN 05	MAL 01 12.4.2008	MAL 02 12.4.2008	MAL 03 12.4.2008	MAL 04 12.4.2008	MAL 05 12.4.2008
PCB 28	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.2	0.7	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 52	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.2	0.3	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 101	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.2	0.6	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 118	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.9	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 153	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	1.4	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 138	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	1.8	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PCB 180	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.3	0.9	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of PCB	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.7	6.1	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
alpha-HCH	0.4	<LOQ	0.1	<LOQ	0.2	202.5	0.4	0.2	0.2	0.2	0.4	0.9	0.2
beta-HCH	0.5	<LOQ	<LOQ	<LOQ	<LOQ	359.8	0.2	1.3	<LOQ	<LOQ	0.3	<LOQ	<LOQ
gamma-HCH	0.3	<LOQ	1.0	0.2	<LOQ	489.2	0.1	0.6	0.2	0.3	0.3	0.2	<LOQ
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	856.8	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of HCH	1.2	<LOQ	1.1	0.2	0.2	1908.4	0.7	2.2	0.4	0.5	1.0	1.0	0.2
o,p'-DDE	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	2 960.2	4.2	6.4	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDE	3.9	0.1	0.3	0.4	1.5	11 085.5	496.8	457.6	<LOQ	1.6	0.8	0.5	0.1
o,p'-DDD	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	417.1	2.0	24.1	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDD	1.9	0.8	0.0	0.1	0.3	1 239.1	15.1	27.1	<LOQ	0.3	0.1	<LOQ	<LOQ
o,p'-DDT	0.9	<LOQ	<LOQ	<LOQ	<LOQ	19 473.2	24.0	321.0	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
p,p'-DDT	6.2	1.2	<LOQ	0.1	0.7	142 527.7	537.2	549.5	<LOQ	1.6	0.5	<LOQ	<LOQ
Sum of DDT	13.0	2.0	0.3	0.6	2.5	174 742.6	1 075.1	1 379.3	<LOQ	3.5	1.4	0.5	0.1
PeCB	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	3.2	0.1	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
HCB	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	2.4	0.2	0.5	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ

Table E 31: Soil concentrations of PCBs and OCPs (ng g⁻¹) at the sampling sites in Africa

SOILS AFRICA 2008											
Koncentrace ng/g											
Sampling site	Mauritius Reduit	Senegal Dakar	South Africa Molopo	South Africa Barbespan	South Africa Vanderbijl Park	South Africa Middelburg	Sudan Khartum	Togo Koumakonda	Tunisia Tunis	Zambia Lusaka IA	
Sample code Collection date	MAU 01	SEN 01	SAF 01 15.4.2008	SAF 02 13.4.2008	SAF 03 14.4.2008	SAF 04 14.4.2008	SUD 01 31.3.2008	TOG 01 3.3.2008	TUN 01 28.4.2008	ZAM 01	
PCB 28	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.2	0.4	<LOQ	<LOQ	
PCB 52	<LOQ	0.2	<LOQ	<LOQ	<LOQ	<LOQ	0.6	0.0	<LOQ	<LOQ	
PCB 101	<LOQ	0.5	<LOQ	<LOQ	<LOQ	<LOQ	1.1	<LOQ	<LOQ	<LOQ	
PCB 118	<LOQ	0.5	<LOQ	<LOQ	<LOQ	<LOQ	0.5	<LOQ	<LOQ	<LOQ	
PCB 153	<LOQ	2.9	<LOQ	<LOQ	0.1	<LOQ	3.7	<LOQ	1.2	<LOQ	
PCB 138	<LOQ	2.2	<LOQ	<LOQ	<LOQ	<LOQ	2.5	<LOQ	1.0	<LOQ	
PCB 180	<LOQ	3.9	<LOQ	<LOQ	<LOQ	<LOQ	7.6	<LOQ	2.1	<LOQ	
Sum of PCB	<LOQ	10.1	<LOQ	<LOQ	0.1	<LOQ	16.2	0.4	4.2	<LOQ	
alpha-HCH	0.7	0.2	<LOQ	<LOQ	0.2	<LOQ	0.2	0.2	0.3	<LOQ	
beta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	
gamma-HCH	0.3	<LOQ	<LOQ	<LOQ	0.2	<LOQ	0.2	0.2	0.1	0.5	
delta-HCH	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	
Sum of HCH	1.0	0.2	<LOQ	<LOQ	0.4	<LOQ	0.4	0.3	0.4	0.5	
o,p'-DDE	<LOQ	1.5	<LOQ	<LOQ	<LOQ	<LOQ	4.1	<LOQ	<LOQ	<LOQ	
p,p'-DDE	4.6	63.2	<LOQ	0.5	1.2	<LOQ	142.6	<LOQ	<LOQ	<LOQ	
o,p'-DDD	<LOQ	1.8	<LOQ	<LOQ	<LOQ	<LOQ	2.2	<LOQ	<LOQ	<LOQ	
p,p'-DDD	0.8	6.7	<LOQ	<LOQ	<LOQ	<LOQ	0.9	<LOQ	<LOQ	<LOQ	
o,p'-DDT	1.1	15.9	<LOQ	<LOQ	<LOQ	<LOQ	10.4	<LOQ	<LOQ	<LOQ	
p,p'-DDT	7.0	110.9	<LOQ	0.4	<LOQ	<LOQ	8.6	<LOQ	0.1	<LOQ	
Sum of DDT	13.4	198.5	<LOQ	0.8	1.2	<LOQ	164.7	<LOQ	0.1	<LOQ	
PeCB	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	
HCB	<LOQ	0.1	<LOQ	<LOQ	0.2	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	

Table E 32: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the sampling site in Congo (ex-site ORSTOM de Brazzaville)

CONGO - Orstom de Brazzaville						
Concentration ng/filter						
Sample code	CON 01 A 01	CON 01 A 02	CON 01 A 03	CON 01 A 06	CON 01 A 07	CON 01 A 08
Collection date	11.1.-11.2.2008	11.2.-11.3.2008	11.3.-8.4.2008	8.4.-6.5.2008	6.5.-3.6.2008	3.6.-1.7.2008
Naphthalene	180	309	356	1 270	678	664
Acenaphthylene	58	75	104	89	121	113
Acenaphthene	26	30	28	34	42	58
Fluorene	299	366	264	339	363	483
Phenanthrene	1 219	1 431	904	1 130	1 183	1 782
Anthracene	113	88	71	87	95	170
Fluoranthene	450	522	285	377	410	660
Pyrene	394	424	247	301	320	597
Benz(a)anthracene	28	25	16	32	21	52
Chrysene	41	45	27	42	44	83
Benzo(b)fluoranthene	17	20	13	17	16	30
Benzo(k)fluoranthene	9	10	6	11	11	15
Benzo(a)pyrene	7	6	6	11	8	14
Indeno(123cd)pyrene	<LOQ	<LOQ	<LOQ	6	5	10
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	<LOQ	<LOQ	<LOQ	8	5	11
Sum of 16 PAHs	2 840	3 350	2 327	3 754	3 320	4 745

Table E 33: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the sampling site in Democratic Republic of Congo, Kinshasa

DEMOCRATIC REPUBLIC OF THE CONGO - Kinshasa								
Concentration ng/filter								
Sampling site	DRC Kinshasa Faculty	DRC Kinshasa library	DRC Kinshasa parish	DRC Kinshasa garden	DRC Kinshasa Eralft	DRC Kinshasa ISTM	DRC Kinshasa traffic	DRC Kinshasa GSMA
Collection date	1.4.-28.4.2008	1.4.-28.4.2008	1.4.-28.4.2008	1.4.-28.4.2008	21.5.-19.6.2008	21.5.-19.6.2008	21.5.-19.6.2008	21.5.-19.6.2008
Naphthalene	368	561	491	423	406	454	606	384
Acenaphthylene	28	60	41	31	33	56	118	49
Acenaphthene	24	40	35	28	35	42	129	33
Fluorene	319	522	507	357	465	543	1 184	485
Phenanthrene	1 705	2 473	3 093	1 674	2 188	2 492	5 503	2 180
Anthracene	79	142	261	73	88	149	429	111
Fluoranthene	876	1 021	1 340	703	965	1 123	2 235	992
Pyrene	770	967	1 128	595	777	973	2 342	879
Benz(a)anthracene	69	51	72	42	55	67	159	61
Chrysene	124	92	117	78	112	121	252	112
Benzo(b)fluoranthene	42	35	29	27	32	32	64	30
Benzo(k)fluoranthene	24	18	17	19	21	19	39	20
Benzo(a)pyrene	9	9	8	<LOQ	<LOQ	10	24	9
Indeno(123cd)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	27	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	41	<LOQ
Sum of 16 PAHs	4 437	5 991	7 139	4 051	5 176	6 080	13 151	5 344

Table E 34: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the urban sampling site in Egypt, Cairo

EGYPT - Cairo						
Concentration ng/filter						
Sample code	EGY 01 A 01	EGY 01 A 02	EGY 01 A 03	EGY 01 A 04	EGY 01 A 05	EGY 01 A 06
Collection date	7.1.-5.2.2008	5.2.-3.3.2008	3.3.-31.3.2008	31.3.-27.4.2008	27.4.-25.5.2008	25.5.-22.6.2008
Naphthalene	968	913	1 180	2 517	237	288
Acenaphthylene	128	120	50	352	16	20
Acenaphthene	184	175	157	713	50	60
Fluorene	958	1 053	1 115	2 225	294	331
Phenanthrene	4 086	5 002	5 897	7 943	2 076	2 377
Anthracene	142	169	197	805	20	27
Fluoranthene	1 847	2 510	3 280	4 369	1 084	1 266
Pyrene	1 260	1 477	1 500	2 618	779	905
Benz(a)anthracene	92	131	234	329	74	46
Chrysene	162	211	321	426	40	177
Benzo(b)fluoranthene	74	116	128	238	50	62
Benzo(k)fluoranthene	34	48	64	102	24	29
Benzo(a)pyrene	32	44	13	103	13	11
Indeno(123cd)pyrene	41	53	73	110	24	27
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	41	52	66	104	28	29
Sum of 16 PAHs	10 050	12 074	14 275	22 954	4 810	5 654

Table E 35: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the urban sampling site in Ethiopia

ETHIOPIA - Asela						
Concentration ng/filter						
Sample code	ETH 01 A 01	ETH 01 A 02	ETH 01 A 03	ETH 01 A 04	ETH 01 A 05	ETH 01 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-31.3.2008	31.3.-2.5.2008	2.5.-5.6.2008	5.6.-4.7.2008
Naphthalene	1 693	1 061	1 356	1 783	886	589
Acenaphthylene	169	63	139	133	185	210
Acenaphthene	406	226	98	140	166	106
Fluorene	1 431	1 125	722	887	1 224	1 212
Phenanthrene	6 362	4 980	3 815	5 237	6 727	7 131
Anthracene	457	188	161	289	565	706
Fluoranthene	2 912	2 133	1 831	3 054	3 547	3 822
Pyrene	2 303	1 430	1 184	2 414	3 064	3 325
Benz(a)anthracene	159	108	102	196	240	264
Chrysene	242	173	194	311	353	369
Benzo(b)fluoranthene	37	47	40	76	66	60
Benzo(k)fluoranthene	28	23	26	41	35	39
Benzo(a)pyrene	21	19	20	22	21	29
Indeno(123cd)pyrene	21	19	21	27	22	27
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	21	19	22	25	20	24
Sum of 16 PAHs	16 262	11 614	9 731	14 634	17 123	17 914

Table E 36: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the sampling site Ghana – Kwabenya

GHANA - Kwabenya						
	Concentration ng/filter					
Sample code	GHA 01 A 01	GHA 01 A 02	GHA 01 A 03	GHA 01 A 04	GHA 01 A 05	GHA 01 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-31.3.2008	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008
Naphthalene	197	238	180	221	7	18
Acenaphthylene	8	8	12	19	6	11
Acenaphthene	17	8	10	16	8	12
Fluorene	260	107	107	153	116	139
Phenanthrene	1 299	678	732	917	870	911
Anthracene	33	22	23	28	25	29
Fluoranthene	525	298	330	364	334	331
Pyrene	353	219	244	267	248	250
Benz(a)anthracene	20	16	18	18	14	14
Chrysene	54	38	42	44	38	35
Benzo(b)fluoranthene	12	10	17	20	13	12
Benzo(k)fluoranthene	6	7	8	11	9	8
Benzo(a)pyrene	2	2	4	2	<LOQ	<LOQ
Indeno(123cd)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of 16 PAHs	2 785	1 650	1 727	2 080	1 689	1 768

Table E 37: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the sampling site Ghana – East Legon

GHANA - East Legon						
	Concentration ng/filter					
Sample code	GHA 02 A 01	MAL 02 A 02	MAL 02 A 03	MAL 02 A 04	MAL 02 A 05	MAL 02 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-31.3.2008	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008
Naphthalene	336	407	274	208	176	187
Acenaphthylene	22	96	23	21	18	22
Acenaphthene	19	28	15	17	14	19
Fluorene	253	243	154	189	160	197
Phenanthrene	1 454	1 579	1 145	1 415	1 197	1 374
Anthracene	49	132	60	70	60	63
Fluoranthene	677	782	633	721	632	649
Pyrene	486	657	526	592	525	551
Benz(a)anthracene	32	61	52	49	48	47
Chrysene	80	107	94	94	89	86
Benzo(b)fluoranthene	26	28	26	37	29	37
Benzo(k)fluoranthene	8	12	14	16	16	17
Benzo(a)pyrene	4	9	8	<LOQ	<LOQ	<LOQ
Indeno(123cd)pyrene	<LOQ	8	8	<LOQ	<LOQ	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	<LOQ	8	10	<LOQ	<LOQ	<LOQ
Sum of 16 PAHs	3 447	4 157	3 044	3 428	2 963	3 249

Table E 38: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the background site Kenya – Mt. Kenya

KENYA - Mt. Kenya						
Concentration ng/filter						
Sample code	KEN 01 A 01	KEN 01 A 02	KEN 01 A 03	KEN 01 A 02	KEN 01 A 03	KEN 01 A 04
Collection date	4.2.-4.3.2008	4.3.-1.4.2008	1.4.-6.5.2008	6.5.-6.6.2008	6.6.-3.7.2008	3.7.-8.8.2008
Naphthalene		93	121	105	54	
Acenaphthylene		1	2	<LOQ	<LOQ	
Acenaphthene		2	2	5	3	
Fluorene		23	19	31	19	
Phenanthrene		47	34	54	43	
Anthracene		1	<LOQ	<LOQ	<LOQ	
Fluoranthene		11	8	8	12	
Pyrene		7	2	5	10	
Benz(a)anthracene		<LOQ	<LOQ	<LOQ	<LOQ	
Chrysene		<LOQ	<LOQ	<LOQ	<LOQ	
Benzo(b)fluoranthene		<LOQ	<LOQ	<LOQ	<LOQ	
Benzo(k)fluoranthene		<LOQ	<LOQ	<LOQ	<LOQ	
Benzo(a)pyrene		<LOQ	<LOQ	<LOQ	<LOQ	
Indeno(123cd)pyrene		<LOQ	<LOQ	<LOQ	<LOQ	
Dibenz(ah)anthracene		<LOQ	<LOQ	<LOQ	<LOQ	
Benzo(ghi)perylene		<LOQ	<LOQ	<LOQ	<LOQ	
Sum of 16 PAHs		186	188	207	140	

Table E 39: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the urban sampling site Kenya – Kabete

KENYA - Kabete						
Concentration ng/filter						
Sample code	KEN 02 A 01	KEN 02 A 02	KEN 02 A 01	KEN 02 A 04	KEN 02 A 05	KEN 02 A 06
Collection date	4.2.-4.3.2008	4.3.-1.4.2008	1.4.-6.5.2008	6.5.-6.6.2008	6.6.-3.7.2008	3.7.-8.8.2008
Naphthalene	248	162	146	344	201	99
Acenaphthylene	21	20	16	14	22	11
Acenaphthene	19	17	18	26	30	23
Fluorene	180	153	166	185	237	195
Phenanthrene	806	667	748	765	943	847
Anthracene	33	28	38	41	45	41
Fluoranthene	343	265	298	332	411	404
Pyrene	253	204	235	263	328	322
Benz(a)anthracene	17	10	15	15	19	26
Chrysene	32	23	27	37	45	47
Benzo(b)fluoranthene	9	6	9	7	12	8
Benzo(k)fluoranthene	5	4	4	6	8	6
Benzo(a)pyrene	3	2	3	2	5	2
Indeno(123cd)pyrene	3	2	2	<LOQ	2	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	4	3	2	2	3	<LOQ
Sum of 16 PAHs	1 977	1 566	1 725	2 038	2 311	2 031

Table E 40: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the sampling site Kenya – Kitengela

KENYA - Kitengela						
Concentration ng/filter						
Sample code	KEN 03 A 01	KEN 03 A 02	KEN 03 A 03	KEN 03 A 04	KEN 03 A 05	KEN 03 A 06
Collection date	4.2.-4.3.2008	5.3.-1.4.2008		7.5.-6.6.2008	6.6.-4.7.2008	4.7.-11.8.2008
Naphthalene	110	270		174	103	94
Acenaphthylene	17	24		32	12	9
Acenaphthene	13	19		25	23	20
Fluorene	112	134		139	137	99
Phenanthrene	528	496		501	388	332
Anthracene	25	22		30	17	14
Fluoranthene	188	173		198	146	123
Pyrene	148	143		164	114	102
Benz(a)anthracene	9	8		7	5	4
Chrysene	17	15		21	13	14
Benzo(b)fluoranthene	7	4		4	2	3
Benzo(k)fluoranthene	3	4		5	3	2
Benzo(a)pyrene	2	1		2	3	<LOQ
Indeno(123cd)pyrene	<LOQ	1		<LOQ	<LOQ	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ		<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	1	1		<LOQ	<LOQ	<LOQ
Sum of 16 PAHs	1 181	1 315		1 303	966	816

Table E 41: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the sampling site Kenya – Industrial area

KENYA - Industrial site						
Concentration ng/filter						
Sample code	KEN 04 A 01	KEN 04 A 02	KEN 04 A 03	KEN 04 A 04	KEN 04 A 05	KEN 04 A 06
Collection date	3.2.-4.3.2008	4.3.-1.4.2008	1.4.-6.5.2008	6.5.-6.6.2008	6.6.-4.7.2008	4.7.-8.8.2008
Naphthalene	216	391	184	187	322	258
Acenaphthylene	63	111	52	56	86	61
Acenaphthene	49	84	63	47	69	67
Fluorene	467	686	483	438	521	556
Phenanthrene	3 000	3 278	2 459	2 368	2 384	2 679
Anthracene	238	302	272	249	195	225
Fluoranthene	1 789	1 611	1 409	1 445	1 180	1 364
Pyrene	1 756	1 593	1 454	1 429	1 118	1 355
Benz(a)anthracene	120	119	104	124	98	95
Chrysene	172	161	133	163	135	136
Benzo(b)fluoranthene	42	41	43	38	34	29
Benzo(k)fluoranthene	18	19	16	24	19	20
Benzo(a)pyrene	17	17	17	22	18	14
Indeno(123cd)pyrene	16	15	15	20	13	13
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	2	2
Benzo(ghi)perylene	19	17	18	23	19	15
Sum of 16 PAHs	7 981	8 444	6 724	6 630	6 211	6 889

Table E 42: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the sampling site Kenya – Dandora

KENYA - Dandora						
Concentration ng/filter						
Sample code	KEN 05 A 01	KEN 05 A 02	KEN 05 A 03	KEN 05 A 04	KEN 05 A 05	KEN 05 A 06
Collection date	5.2.-4.3.2008	4.3.-1.4.2008	1.4.-6.5.2008	6.5.-6.6.2008	6.6.-4.7.2008	4.7.-8.8.2008
Naphthalene	170	143	153	206	334	242
Acenaphthylene	69	59	74	64	123	53
Acenaphthene	79	74	64	98	76	64
Fluorene	600	724	606	723	774	748
Phenanthrene	3 189	3 867	3 436	3 190	3 511	3 967
Anthracene	239	359	300	272	254	336
Fluoranthene	1 183	1 591	1 467	1 367	1 541	1 984
Pyrene	974	1 429	1 406	1 380	1 428	1 852
Benz(a)anthracene	77	100	98	108	95	127
Chrysene	96	133	133	139	137	180
Benzo(b)fluoranthene	25	37	29	36	38	43
Benzo(k)fluoranthene	11	14	15	24	23	26
Benzo(a)pyrene	11	15	13	19	21	5
Indeno(123cd)pyrene	8	13	10	19	18	24
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	1	2	2
Benzo(ghi)perylene	9	14	12	23	24	24
Sum of 16 PAHs	6 742	8 574	7 817	7 669	8 402	9 676

Table E 43: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the background sampling site Mali – Tomboucutou

MALI- Tomboucutou						
Concentration ng/filter						
Sample code	MAL 01 A 01	MAL 01 A 02	MAL 01 A 03	MAL 01 A 04	MAL 01 A 05	MAL 01 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-12.4.2008	12.4.-11.5.2008	11.5.-8.6.2008	8.6.-5.7.2008
Naphthalene	389	185	146	184	576	362
Acenaphthylene	5	3	4	3	7	7
Acenaphthene	6	5	3	4	10	10
Fluorene	38	61	21	28	41	32
Phenanthrene	125	364	91	162	187	157
Anthracene	4	15	2	5	5	6
Fluoranthene	46	143	40	66	42	71
Pyrene	27	87	25	40	20	40
Benz(a)anthracene	3	7	3	4	<LOQ	5
Chrysene	9	16	8	17	5	22
Benzo(b)fluoranthene	8	9	8	11	<LOQ	14
Benzo(k)fluoranthene	5	5	5	15	<LOQ	14
Benzo(a)pyrene	4	5	5	<LOQ	<LOQ	<LOQ
Indeno(123cd)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	9
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of 16 PAHs	669	904	361	539	894	750

Table E 44: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the urban sampling site Mali – Bamako centre

MALI - Bamako centre						
	Concentration ng/filter					
Sample code	MAL 02 A 01	MAL 02 A 02	MAL 02 A 03	MAL 02 A 04	MAL 02 A 05	MAL 02 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-12.4.2008	12.4.-10.5.2008	10.5.-8.6.2008	8.6.-5.7.2008
Naphthalene	541	304	558	991	127	432
Acenaphthylene	115	51	91	50	14	51
Acenaphthene	39	25	26	24	9	27
Fluorene	427	331	216	262	133	313
Phenanthrene	2 094	2 216	1 470	2 119	1 315	1 968
Anthracene	180	176	92	116	54	108
Fluoranthene	916	1 141	877	1 240	786	1 063
Pyrene	805	1 014	758	1 078	656	910
Benz(a)anthracene	61	83	67	97	66	76
Chrysene	105	139	125	192	134	153
Benzo(b)fluoranthene	34	47	47	77	53	43
Benzo(k)fluoranthene	12	19	18	35	22	24
Benzo(a)pyrene	8	11	9	11	6	10
Indeno(123cd)pyrene	8	14	13	<LOQ	11	11
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	10	16	14	20	14	15
Sum of 16 PAHs	5 351	5 588	4 380	6 311	3 400	5 204

Table E 45: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the sampling site Mali – Bamako international airport

MALI - Bamako airport						
	Concentration ng/filter					
Sample code	MAL 03 A 01	MAL 03 A 02	MAL 03 A 03	MAL 03 A 04	MAL 03 A 05	MAL 03 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-12.4.2008	12.4.-10.5.2008	10.5.-8.6.2008	8.6.-5.7.2008
Naphthalene	693	249	207	1 683	221	232
Acenaphthylene	8	8	3	10	3	16
Acenaphthene	11	8	4	23	6	17
Fluorene	112	94	47	110	69	145
Phenanthrene	595	576	387	504	648	687
Anthracene	16	15	9	11	18	20
Fluoranthene	9	249	222	224	290	306
Pyrene	188	194	155	162	225	241
Benz(a)anthracene	10	13	10	10	13	17
Chrysene	29	32	34	34	39	42
Benzo(b)fluoranthene	8	15	13	12	14	13
Benzo(k)fluoranthene	5	6	6	8	9	12
Benzo(a)pyrene	2	3	2	<LOQ	<LOQ	<LOQ
Indeno(123cd)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of 16 PAHs	1 687	1 462	1 101	2 791	1 555	1 746

Table E 46: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the agricultural sampling site Mali – Koutiala

MALI - Koutiala						
Concentration ng/filter						
Sample code	MAL 04 A 01	MAL 04 A 02	MAL 04 A 03	MAL 04 A 04	MAL 04 A 05	MAL 04 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-12.4.2008	12.4.-10.5.2008	10.5.-7.6.2008	7.6.-5.7.2008
Naphthalene	1 326	644	96	221	187	162
Acenaphthylene	404	254	24	12	19	35
Acenaphthene	76	46	16	23	10	22
Fluorene	1 060	759	274	165	171	297
Phenanthrene	5 943	5 094	2 602	1 822	1 963	2 073
Anthracene	652	592	193	92	103	173
Fluoranthene	3 277	3 131	2 007	1 573	1 623	1 389
Pyrene	2 850	2 733	1 690	1 300	1 283	1 177
Benz(a)anthracene	216	230	152	150	169	158
Chrysene	283	316	267	285	297	246
Benzo(b)fluoranthene	79	67	99	97	108	89
Benzo(k)fluoranthene	34	36	37	52	57	40
Benzo(a)pyrene	28	32	16	11	21	23
Indeno(123cd)pyrene	27	25	21	<LOQ	<LOQ	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	25	23	20	27	25	<LOQ
Sum of 16 PAHs	16 278	13 981	7 515	5 832	6 035	5 885

Table E 47: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the agricultural sampling site Mali – Niono

MALI - Niono						
Concentration ng/filter						
Sample code	MAL 05 A 01	MAL 05 A 02	MAL 05 A 03	MAL 05 A 04	MAL 05 A 05	MAL 05 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-12.4.2008	12.4.-10.5.2008	10.5.-8.6.2008	8.6.-5.7.2008
Naphthalene	491	385	181	1 272	236	405
Acenaphthylene	4	19	12	33	18	31
Acenaphthene	4	17	5	25	13	25
Fluorene	49	72	34	174	147	221
Phenanthrene	226	298	182	942	840	1 120
Anthracene	12	12	8	42	37	65
Fluoranthene	93	103	85	509	463	605
Pyrene	65	67	50	327	308	469
Benz(a)anthracene	6	3	4	30	27	46
Chrysene	16	10	10	62	61	96
Benzo(b)fluoranthene	3	3	4	26	23	29
Benzo(k)fluoranthene	3	2	3	16	16	21
Benzo(a)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	6	<LOQ
Indeno(123cd)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of 16 PAHs	973	990	579	3 458	2 194	3 132

Table E 48: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the background sampling site in Mauritius, Reduit

MAURITIUS - Reduit						
	Concentration ng/filter					
Sample code	MAU01A01	MAU01A02	MAU01A03	MAU 01 A 04	MAU 01 A 05	MAU 01 A 06
Collection date	7.1.-8.2.08	8.2.-3.3.08	3.3.-31.3.08	31.3.-28.4.2008	28.4.-10.6.2008	10.6.-24.6.2008
Naphthalene	580	971	1 688	3 208	1 794	1 322
Acenaphthylene	19	26	45	96	52	27
Acenaphthene	7	13	28	65	44	21
Fluorene	60	72	84	190	195	103
Phenanthrene	388	341	342	771	1 003	401
Anthracene	79	63	58	142	144	63
Fluoranthene	223	139	147	372	524	174
Pyrene	377	225	229	529	739	269
Benz(a)anthracene	13	5	5	17	20	7
Chrysene	17	9	10	22	31	10
Benzo(b)fluoranthene	9	5	4	7	14	6
Benzo(k)fluoranthene	5	2	3	6	9	2
Benzo(a)pyrene	6	3	3	8	6	<LOQ
Indeno(123cd)pyrene	3	2	1	<LOQ	6	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	8	3	4	<LOQ	15	<LOQ
Sum of 16 PAHs	1 791	1 880	2 651	5 433	4 593	2 406

Table E 49: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the agricultural sampling site in Nigeria

NIGERIA - Sheda						
	Concentration ng/filter					
Sample code	NIG 01 A 01	NIG 01 A 02	NIG 01 A 03	NIG 01 A 04	NIG 01 A 05	NIG 01 A 06
Collection date	7.1.-4.2.2008	7.2.-3.3.2008	3.3.-31.3.2008	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008
Naphthalene	1 641	922	459	236	756	617
Acenaphthylene	28	9	6	31	10	14
Acenaphthene	36	13	5	26	12	13
Fluorene	382	147	45	268	108	123
Phenanthrene	2 243	1 915	429	1 832	860	812
Anthracene	70	39	13	97	29	39
Fluoranthene	847	1 035	215	907	414	389
Pyrene	620	722	171	757	333	332
Benz(a)anthracene	27	27	9	71	22	23
Chrysene	90	127	32	128	70	60
Benzo(b)fluoranthene	19	42	11	42	23	18
Benzo(k)fluoranthene	7	12	5	22	12	10
Benzo(a)pyrene	3	3	2	9	<LOQ	<LOQ
Indeno(123cd)pyrene	5	9	2	8	<LOQ	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	6	10	3	11	<LOQ	<LOQ
Sum of 16 PAHs	6 024	5 031	1 407	4 446	2 649	2 450

Table E 50: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the urban sampling site in Senegal, Dakar

SENEGAL - Dakar						
	Concentration ng/filter					
Sample code	SEN 01 A 01	SEN 01 A 02	SEN 01 A 03	SEN 01 A 04	SEN 01 A 05	SEN 01 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-31.3.2008		28.4.-26.5.2008	26.5.-23.6.2008
Naphthalene	263	341	370		166	67
Acenaphthylene	85	104	78		36	24
Acenaphthene	131	99	75		66	30
Fluorene	694	647	499		399	274
Phenanthrene	3 408	4 626	3 938		4 932	2 468
Anthracene	201	235	203		217	119
Fluoranthene	1 249	1 924	1 731		3 049	1 081
Pyrene	1 202	2 007	1 668		2 816	1 074
Benz(a)anthracene	107	181	152		346	115
Chrysene	155	274	238		556	203
Benzo(b)fluoranthene	45	78	74		265	85
Benzo(k)fluoranthene	23	40	34		125	44
Benzo(a)pyrene	23	31	28		95	25
Indeno(123cd)pyrene	19	30	29		103	29
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ		11	<LOQ
Benzo(ghi)perylene	24	36	35		107	35
Sum of 16 PAHs	7 627	10 655	9 151		13 289	5 671

Table E 51: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the background sampling site South Africa – Molopo

SOUTH AFRICA - Molopo Nature reservation							
	Concentration ng/filter						
Sample code	SAF 01 A 01	SAF 01 A 02	SAF 01 A 03	SAF 01 A 04	SAF 01 A 05	SAF 01 A 06	SAF 01 A 07
Collection date	15.1.-12.2.2008	12.2.-11.3.2008	12.3.-15.4.2008	15.4.-12.5.2008	12.5.-6.6.2008	6.6.-3.7.2008	3.7.-31.7.2008
Naphthalene	189	209	41	259	258	501	202
Acenaphthylene	2	2	<LOQ	1	1	3	1
Acenaphthene	7	8	5	5	6	7	5
Fluorene	14	16	19	15	14	22	33
Phenanthrene	84	109	146	110	66	72	109
Anthracene	4	5	4	<LOQ	<LOQ	<LOQ	<LOQ
Fluoranthene	29	42	52	45	18	20	33
Pyrene	14	19	30	20	14	11	25
Benz(a)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Chrysene	<LOQ	1	2	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(b)fluoranthene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(k)fluoranthene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(a)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Indeno(123cd)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of 16 PAHs	345	411	299	454	378	636	408

Table E 52: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the background sampling site South Africa – Barberspan

SOUTH AFRICA - Barberspan							
	Concentration ng/filter						
Sample code	SAF 02 A 01	SAF 02 A 02	SAF 02 A 03	SAF 02 A 04	SAF 02 A 05	SAF 02 A 06	SAF 02 A 07
Collection date	15.1.-12.2.2008	12.2.-10.3.2008	10.3.-13.4.2008	13.4.-12.5.2008	12.5.-6.6.2008	6.6.-3.7.2008	3.7.-31.7.2008
Naphthalene	316	192	82	229	150	376	179
Acenaphthylene	3	2	<LOQ	2	2	2	2
Acenaphthene	11	6	5	10	7	12	10
Fluorene	30	22	27	33	31	38	44
Phenanthrene	79	59	79	93	80	93	115
Anthracene	2	2	2	1	<LOQ	<LOQ	<LOQ
Fluoranthene	20	14	20	19	20	22	27
Pyrene	10	6	12	13	13	17	21
Benz(a)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Chrysene	1	<LOQ	1	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(b)fluoranthene	<LOQ	<LOQ	1	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(k)fluoranthene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(a)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Indeno(123cd)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of 16 PAHs	473	303	229	401	303	560	398

Table E 53: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the industrial sampling site South Africa – Vanderbijl Park

SOUTH AFRICA - Vanderbijl Park							
	Concentration ng/filter						
Sample code	SAF 03 A 01	SAF 03 A 02	SAF 03 A 03	SAF 03 A 04	SAF 03 A 05	SAF 03 A 06	SAF 03 A 07
Collection date	15.1.-12.2.2008	12.2.-10.3.2008	10.3.-14.4.2008	14.4.-12.5.2008	12.5.-6.6.2008	6.6.-3.7.2008	3.7.-31.7.2008
Naphthalene	350	299	392	688	587	1 580	383
Acenaphthylene	9	27	15	34	37	55	22
Acenaphthene	65	67	101	129	137	206	109
Fluorene	706	702	716	712	699	1 147	551
Phenanthrene	2 299	2 108	2 066	1 933	1 865	2 549	1 397
Anthracene	132	183	170	149	153	218	89
Fluoranthene	1 323	994	967	809	900	1 079	514
Pyrene	802	562	585	491	573	662	313
Benz(a)anthracene	75	53	58	53	58	58	<LOQ
Chrysene	105	78	86	88	<LOQ	96	49
Benzo(b)fluoranthene	51	42	36	47	32	58	17
Benzo(k)fluoranthene	15	14	15	27	29	25	17
Benzo(a)pyrene	9	11	12	21	24	24	17
Indeno(123cd)pyrene	8	10	11	14	19	19	16
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	2	<LOQ	1	1
Benzo(ghi)perylene	10	11	12	20	26	21	20
Sum of 16 PAHs	5 961	5 160	5 242	5 218	5 139	7 799	3 517

Table E 54: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the background sampling site in Sudan

SUDAN - Khartum						
Concentration ng/filter						
Sample code	SUD01A01	SUD01A02	SUD01A03	SUD 01 A 04	SUD 01 A 05	SUD 01 A 06
Collection date	7.1.-4.2.08	4.2.-3.3.08	3.3.-31.3.08	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008
Naphthalene	316	195	273	243	314	184
Acenaphthylene	26	22	18	31	18	19
Acenaphthene	29	23	17	22	16	14
Fluorene	389	370	239	298	171	167
Phenanthrene	1 799	1 899	1 725	2 207	1 515	1 383
Anthracene	61	115	129	95	63	58
Fluoranthene	780	839	881	1 160	818	671
Pyrene	638	686	881	736	547	412
Benz(a)anthracene	41	48	61	84	72	49
Chrysene	87	109	125	185	150	127
Benzo(b)fluoranthene	34	41	44	99	61	50
Benzo(k)fluoranthene	13	14	17	32	25	26
Benzo(a)pyrene	9	12	9	17	14	12
Indeno(123cd)pyrene	12	14	12	25	17	<LOQ
Dibenz(ah)anthracene	<LOQ	1	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	18	22	20	34	25	<LOQ
Sum of 16 PAHs	4 252	4 412	4 454	5 269	3 825	3 172

Table E 55: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the background sampling site in Togo, Koumakonda

TOGO - Koumakonda						
Concentration ng/filter						
Sample code	TOG 01 A 01	TOG 01 A 02	TOG 01 A 03	TOG 01 A 04	TOG 01 A 05	TOG 01 A 06
Collection date	7.1.-4.2.2008	4.2.-3.3.2008	3.3.-31.3.2008	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008
Naphthalene	1 887	1 483	1 156	1 055	786	368
Acenaphthylene	11	12	10	13	10	7
Acenaphthene	16	12	9	19	8	7
Fluorene	184	93	71	118	85	68
Phenanthrene	1 044	592	395	613	471	305
Anthracene	13	12	12	23	16	14
Fluoranthene	482	259	178	285	229	117
Pyrene	264	159	120	190	141	82
Benz(a)anthracene	9	8	9	17	10	6
Chrysene	47	33	26	43	28	16
Benzo(b)fluoranthene	11	6	10	12	10	<LOQ
Benzo(k)fluoranthene	5	4	5	11	8	<LOQ
Benzo(a)pyrene	2	1	2	<LOQ	<LOQ	<LOQ
Indeno(123cd)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of 16 PAHs	3 975	2 674	2 003	2 399	1 804	990

Table E 56: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the sampling site in Tunisia

TUNISIA - Tunis						
Concentration ng/filter						
Sample code	TUN 01 A 01	TUN 01 A 02	TUN 01 A 03	TUN 01 A 04	TUN 01 A 05	TUN 01 A 06
Collection date	4.2.-3.3.2008	3.3.-31.3.2008	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008	23.6.-21.7.2008
Naphthalene	496	758	736	815	801	1 110
Acenaphthylene	22	21	18	47	33	40
Acenaphthene	31	33	38	110	96	135
Fluorene	242	103	112	206	177	162
Phenanthrene	978	134	143	436	347	307
Anthracene	26	9	8	3	8	2
Fluoranthene	295	17	16	68	68	40
Pyrene	224	11	12	31	20	19
Benz(a)anthracene	10	<LOQ	<LOQ	2	1	<LOQ
Chrysene	26	<LOQ	<LOQ	3	2	2
Benzo(b)fluoranthene	8	<LOQ	<LOQ	1	<LOQ	<LOQ
Benzo(k)fluoranthene	3	<LOQ	<LOQ	2	<LOQ	<LOQ
Benzo(a)pyrene	2	<LOQ	<LOQ	<LOQ	1	<LOQ
Indeno(123cd)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sum of 16 PAHs	2 361	1 086	1 083	1 724	1 554	1 817

Table E 57: Temporal variations of PAH concentrations in the ambient air (ng filter⁻¹) at the sampling site in Zambia

ZAMBIA - Lusaka IA						
Concentration ng/filter						
Sample code	ZAM 01 A 01	ZAM 01 A 02	ZAM 01 A 03	ZAM 01 A 04	ZAM 01 A 05	ZAM 01 A 06
Collection date	7.1.-4.2.2008	7.2.-3.3.2008	3.3.-31.3.2008	31.3.-28.4.2008	28.4.-26.5.2008	26.5.-23.6.2008
Naphthalene	1 131	1 463	545	1 387	561	518
Acenaphthylene	9	9	4	5	5	3
Acenaphthene	7	12	6	10	11	21
Fluorene	44	69	34	79	88	128
Phenanthrene	254	358	147	375	380	481
Anthracene	15	23	10	26	22	27
Fluoranthene	77	118	43	145	140	181
Pyrene	62	90	34	116	111	139
Benz(a)anthracene	4	6	2	8	7	9
Chrysene	8	13	4	20	17	23
Benzo(b)fluoranthene	4	5	2	6	7	6
Benzo(k)fluoranthene	2	3	<LOQ	3	2	3
Benzo(a)pyrene	1	2	<LOQ	1	1	2
Indeno(123cd)pyrene	<LOQ	<LOQ	<LOQ	<LOQ	1	2
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	<LOQ	<LOQ	<LOQ	1	2	3
Sum of 16 PAHs	1 619	2 170	831	2 181	1 355	1 545

Table E 58: Statistical evaluation of PAH concentrations determined in the passive air samples

16 PAHs	MIN	MAX	MEAN	MEDIAN
	ng filter ⁻¹	ng filter ⁻¹	ng filter ⁻¹	ng filter ⁻¹
Congo	2 328	4 745	3 390	3 336
DR Congo	4 053	13 151	6 423	5 669
Egypt	4 810	22 954	11 636	11 062
Ethiopia	9 731	17 915	14 547	15 449
Ghana 01	1 652	2 786	1 951	1 749
Ghana 02	2 965	4 158	3 383	3 341
Kenya 01	145	212	185	191
Kenya 02	1 566	2 312	1 942	2 005
Kenya 03	818	1 316	1 117	1 182
Kenya 04	6 211	8 445	7 147	6 807
Kenya 05	6 742	9 676	8 147	8 110
Mali 01	362	905	688	711
Mali 02	3 401	6 312	5 040	5 278
Mali 03	1 102	2 793	1 726	1 623
Mali 04	5 833	16 278	9 255	6 776
Mali 05	581	3 460	1 890	1 594
Mauritius	1 792	5 434	3 127	2 529
Nigeria	1 408	6 025	3 669	3 549
Senegal	5 672	13 289	9 279	9 152
South Africa 01	303	640	423	413
South Africa 02	233	564	385	402
South Africa 03	3 518	7 799	5 434	5 218
Sudan	3 174	5 269	4 231	4 332
Togo	993	3 977	2 310	2 203
Tunisia	1 087	2 362	1 607	1 641
Zambia	834	2 182	1 618	1 583

Table E 59: Soil concentrations of PAHs (ng g⁻¹) at the sampling sites in Africa

SOILS AFRICA													
Concentration ng g ⁻¹													
Sampling site	Ethiopia Asela	Ghana Kwabanya	Ghana East Legon	Kenya Mt.Kenya	Kenya Kabete	Kenya Klergela	Kenya Industrial site	Kenya Dandora	Mali Tombuctu	Mali Bamako centre	Mali airport	Mali	Mali Koutiala
Sample code	ETH 01	GHA 01	GHA 02	KEN 01	KEN 02	KEN 03	KEN 04	KEN 05	MAL 01	MAL 02	MAL 03	MAL 04	MAL 05
Collection date	12.4.08	12.4.08	12.4.08	13.5.08					12.4.08	12.4.08	12.4.08	12.4.08	12.4.08
Naphthalene	27.6	4.6	4.3	4.2	3.5	2.6	8.1	8.9	2.8	7.2	7.4	3.6	2.7
Acenaphthylene	3.4	<LOQ	0.2	0.1	0.1	1.4	2.3	1.4	<LOQ	<LOQ	0.5	0.4	0.2
Acenaphthene	0.7	<LOQ	<LOQ	0.2	<LOQ	5.4	1.0	0.7	0.4	<LOQ	0.6	0.4	<LOQ
Fluorene	6.0	0.4	0.4	0.5	0.2	5.4	2.5	3.1	0.3	0.2	1.8	2.2	0.2
Phenanthrene	24.5	1.3	2.1	2.3	1.0	1.8	18.2	20.5	2.4	1.8	5.7	13.5	0.3
Anthracene	1.5	0.2	<LOQ	0.1	<LOQ	0.7	5.5	4.4	<LOQ	<LOQ	0.5	1.0	<LOQ
Fluoranthene	6.9	1.6	3.5	1.0	1.0	0.2	28.8	23.2	4.7	0.7	1.5	10.5	0.1
Pyrene	5.1	1.4	2.9	0.8	0.9	0.4	25.7	26.3	3.7	<LOQ	1.1	8.4	<LOQ
Benz(a)anthracene	0.6	0.4	0.8	0.2	0.4	<LOQ	11.9	9.0	1.0	<LOQ	<LOQ	0.6	<LOQ
Chrysene	1.2	0.6	1.4	0.4	0.7	<LOQ	17.1	14.3	3.2	<LOQ	0.2	1.2	<LOQ
Benzo(b)fluoranthene	1.2	1.0	1.4	0.3	0.9	<LOQ	26.9	20.6	5.1	<LOQ	0.4	1.0	<LOQ
Benzo(k)fluoranthene	0.6	0.6	1.1	0.6	0.4	<LOQ	9.3	7.0	2.4	<LOQ	0.2	0.5	<LOQ
Benzo(a)pyrene	0.5	0.8	2.6	0.4	0.4	<LOQ	18.1	15.0	3.6	<LOQ	0.5	1.0	<LOQ
Indeno(123cd)pyrene	0.7	0.9	2.1	0.4	1.0	0.1	18.8	17.6	3.5	<LOQ	<LOQ	0.9	<LOQ
Dibenz(ah)anthracene	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	2.8	1.4	0.7	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	0.6	0.9	1.9	<LOQ	<LOQ	0.3	21.8	24.5	3.4	<LOQ	<LOQ	1.0	<LOQ
Sum of PAHs	81.10	14.70	24.70	11.50	10.50	18.30	218.80	197.90	37.20	9.90	20.40	46.20	3.50

Table E 60: Soil concentrations of PAHs (ng g⁻¹) at the sampling sites in Africa

SOILS AFRICA										
Concentration ng g ⁻¹										
Sampling site	Mauritius Reduit	Senegal Dakar	South Africa Molopo	South Africa Barbespan	South Africa Vanderbijl Park	South Africa Middelburg	Sudan	Khartum	Togo Koumakonda	Tunisia Tunis
Sample code	MAU 01	SEN 01	SAF 01	SAF 02	SAF 03	SAF 04	SUD 01	TOG 01	TUN 01	Zambia Lusaka IA
Collection date			15.4.08	13.4.08	14.4.08	14.4.08	31.3.08	3.3.08	28.4.08	
Naphthalene	22.4	2.3	2.1	2.5	5.5	5.3	5.3	11.5	5.7	23.5
Acenaphthylene	2.3	1.7	<LOQ	<LOQ	0.3	<LOQ	0.4	0.6	0.4	1.0
Acenaphthene	1.5	0.4	<LOQ	<LOQ	0.3	<LOQ	0.9	0.4	0.6	8.8
Fluorene	2.5	0.7	<LOQ	<LOQ	0.8	0.5	2.4	2.3	0.8	6.5
Phenanthrene	13.7	8.6	0.3	3.0	9.9	5.2	4.4	2.9	2.7	5.9
Anthracene	1.7	4.2	<LOQ	<LOQ	1.0	0.4	<LOQ	0.2	0.1	<LOQ
Fluoranthene	23.6	20.6	<LOQ	9.1	17.3	3.5	2.0	0.8	2.3	0.7
Pyrene	19.4	20.4	<LOQ	7.4	12.0	2.3	1.8	0.7	2.3	0.4
Benz(a)anthracene	6.6	9.0	<LOQ	3.4	5.8	0.9	0.6	0.2	1.2	<LOQ
Chrysene	10.2	11.0	<LOQ	4.8	8.7	2.1	0.9	0.4	1.6	<LOQ
Benzo(b)fluoranthene	15.5	17.4	<LOQ	7.9	12.9	3.5	1.2	1.1	3.1	<LOQ
Benzo(k)fluoranthene	6.3	6.7	<LOQ	3.9	5.8	1.2	0.8	0.3	1.5	<LOQ
Benzo(a)pyrene	10.3	12.8	<LOQ	6.2	9.8	1.6	1.2	3.0	3.0	<LOQ
Indeno(123cd)pyrene	13.5	11.8	<LOQ	7.2	9.5	1.8	1.1	0.4	3.3	<LOQ
Dibenz(ah)anthracene	2.2	1.0	<LOQ	1.2	0.8	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Benzo(ghi)perylene	16.8	14.6	<LOQ	8.1	9.6	2.3	1.3	<LOQ	4.0	<LOQ
Sum of PAHs	168.50	143.20	2.40	64.70	110.00	30.60	24.30	24.80	32.60	46.80

Table E 61: Statistical evaluation of HCH concentrations determined in the passive air samples

HCHs	MIN	MAX	MEAN	MEDIAN
	ng filter ⁻¹	ng filter ⁻¹	ng filter ⁻¹	ng filter ⁻¹
Congo	10.2	14.8	12.9	13.4
DR Congo	6.8	16.0	12.6	13.8
Egypt	34.1	101.8	60.3	47.1
Ethiopia	1.2	38.5	16.5	13.9
Ghana 01	6.3	9.2	8.1	8.4
Ghana 02	3.3	17.7	9.1	7.9
Kenya 01	4.9	19.7	9.9	7.5
Kenya 02	4.6	30.9	10.5	7.0
Kenya 03	1939.1	9307.5	4517.0	2451.3
Kenya 04	1.7	18.8	9.1	8.3
Kenya 05	1.5	23.6	14.0	13.5
Mali 01	1.9	7.4	4.0	3.5
Mali 02	6.9	45.1	22.3	17.8
Mali 03	4.9	29.4	14.1	9.1
Mali 04	3.4	17.7	10.4	10.2
Mali 05	3.0	7.2	4.5	4.3
Mauritius	2.3	15.6	6.8	4.9
Nigeria	3.6	10.1	6.9	7.5
Senegal	9.9	29.1	20.1	21.2
South Africa 01	2.0	8.9	4.7	4.0
South Africa 02	2.3	12.3	7.1	4.9
South Africa 03	8.7	43.7	23.4	21.4
Sudan	7.5	18.0	12.4	12.0
Togo	19.7	147.4	60.8	43.3
Tunisia	16.8	17014.4	2860.4	34.0
Zambia	2.0	9.3	4.2	3.5

Table E 62: Statistical evaluation of PeCB concentrations determined in the passive air samples

PeCB	MIN	MAX	MEAN	MEDIAN
	ng filter ⁻¹	ng filter ⁻¹	ng filter ⁻¹	ng filter ⁻¹
Congo	0.3	1.7	0.9	0.9
DR Congo	0.1	0.8	0.4	0.3
Egypt	8.7	33.0	20.7	22.5
Ethiopia	0.1	1.5	0.9	1.1
Ghana 01	0.3	1.5	0.8	0.7
Ghana 02	0.1	1.2	0.7	0.8
Kenya 01	0.4	1.0	0.6	0.5
Kenya 02	0.1	1.2	0.5	0.3
Kenya 03	6.6	13.8	11.0	11.4
Kenya 04	1.5	3.2	2.2	2.1
Kenya 05	2.6	13.0	6.9	6.0
Mali 01	0.1	1.5	0.6	0.5
Mali 02	0.3	3.3	1.3	0.9
Mali 03	0.1	1.2	0.6	0.5
Mali 04	0.1	1.7	0.8	0.6
Mali 05	0.1	1.8	0.6	0.4
Mauritius	0.1	0.9	0.4	0.4
Nigeria	0.1	1.5	0.7	0.8
Senegal	0.1	1.4	0.7	0.9
South Africa 01	0.1	0.9	0.4	0.2
South Africa 02	0.1	0.9	0.5	0.5
South Africa 03	0.1	1.2	0.6	0.8
Sudan	1.0	2.4	1.6	1.5
Togo	0.3	1.9	1.1	1.2
Tunisia	0.1	37.4	6.9	1.0
Zambia	0.5	0.9	0.7	0.7

Table E 63 : WHO PCDD/F-TEQ and PCB-TEQ from Egypt (3rd round)

Indicator	Level (pg/g fat)
WHO-PCDD/F-TEQ	22.33
WHO-PCB-TEQ	5.48

Table E 64: Concentrations of the basic POPs in Human Milk (Sudan, 4th round)

Basic POPs	Conc (ng/g fat)
Aldrin	ND
Chlordane group 1)	12,8
α-chlordane	ND
β-chlordane	ND
oxy-chlordane	13,2
trans-nonachlor	3,4
Dieldrin	1,4
DDT group2)	1300
o,p'-DDD	ND
p,p'-DDD	3,2
o,p'-DDE	2,2
P,p'-DDE	1093
O,p'-DDT	12,2
P,p'-DDT	65,9
Endrin group 3)	ND
Endrin	ND
Endrin ketone	ND
Heptachlor group 4)	3,5
Heptachlor	ND
Heptachlor-epoxide cis	3,6
Heptachlor-epoxide trans	ND
Hexachlorobenzene	3,2
Hexachlorocyclohexane(HCH) group	
α-HCH	ND
β-HCH	36,5
γ-HCH	ND
Parlar(toxaphene) group 5)	ND
Parlar 26	ND
Parlar 50	ND
Parlar 62	ND
Mirex	ND

Explanation

ND=Not Detected (<0.5 ng/g fat)

1) sum of alpha-chlordane, beta-chlordane and oxychlordane, calculated as chlordane

2) sum of o,p'-DDT, p,p'-DDT, p,p'-DDE, and p,p'-DDD, calculated as DDT

3) sum of endrin and endrin ketone, calculated as endrin

4) sum of heptachlor and heptachlor-epoxide(cis/trans), calculated as heptachlor

5) sum of parlar 26, parlar 50 and parlar 62

Table E 65: Concentrations of PCBs in Human Milk (Sudan, 4th round)

PCBs	Sudan
Indicator-PCB	Conc (ng/g fat)
PCB 28	0,65
PCB 52	0,31
PCB 101	0,31
PCB 138	15,0
PCB 153	21,5
PCB 180	11,3
Sum indicator PCBs	49,1
Mono-ortho PCB	Conc (ng/g fat)
PCB 105	2,51
PCB 114	0,30
PCB 118	8,44
PCB 123	0,09
PCB 156	2,85
PCB 157	0,36
PCB 167	0,75
PCB 189	0,17
Non-ortho PCB	Conc (pg/g fat)
PCB 77	4,59
PCB 81	< 2
PCB 126	12,5
PCB 169	4,5
WHO-mono ortho PCB-TEQ	2,9
WHO-non ortho PCB-TEQ	1,3
WHO-PCB-TEQ	4,2

Explanation:

< = below LOQ (calculation of TEQ including full LOQ)

Table E 66: Concentrations of dioxins and furans in Human Milk (Sudan, 4th round)

DIOXINS/FURANS	Conc (pg/g fat)
2,3,7,8-substituted PCDD/PCDF-congeners	
2,3,7,8-TCDD	0,57
1,2,3,7,8-PeCDD	1,59
1,2,3,4,7,8-HxCDD	0,75
1,2,3,6,7,8-HxCDD	3,38
1,2,3,7,8,9-HxCDD	1,88
1,2,3,4,6,7,8-HpCDD	8,10
OCDD	18,8
2,3,7,8-TCDF	0,57
1,2,3,7,8-PeCDF	0,46
2,3,4,7,8-PeCDF	5,46
1,2,3,4,7,8-HxCDF	2,20
1,2,3,6,7,8-HxCDF	2,00
2,3,4,6,7,8-HxCDF	0,94
1,2,3,7,8,9-HxCDF	0,12
1,2,3,4,6,7,8-HpCDF	0,94
1,2,3,4,7,8,9-HpCDF	0,12
OCDF	0,12
WHO-PCDD/F-TEQ	6,2

Explanation

< = below LOQ (calculation of TEQ including full LOQ)

Table E 67: Concentrations (ng/g) of POPs residues in human milk fat and whole milk from South Africa (2006)

POPs	Whole Milk	Milk Fat
DDT	34,3	1164,9
DDE	57,3	1716,6
DDD	2,8	85,7

Source: Bouwman et al. (2006)

Table E 68: POPs residues in human milk from South Africa (2006)

Pesticides	Levels (µg/kg)
DDT	1199.2
DDE	1773.9
DDD	88.5

Table E 69: Levels (ng/g) of organochlorine pesticide residues in water and sediments from South Africa (2003)

	Water (ng/g)	Sediment (ng/g)
HCB	209.7	63.1
Heptachlore	48.0	22.3
Aldrin	36.2	8.4
DDE	36.7	4.5
Dieldrin	26.1	5.8
DDD	111.7	18.5
Endrin	21.1	11.2
DDT	215.0	20.9

Table E 70: POP pesticides in human blood from Ghana (2008)

Pesticides	Milk	Blood
DDE	44.8	7.1
DDD	8	0
DDT	31.4	0.5
Dieldrin	122.8	127
HCB	4.9	5.3

Table E 71: Concentrations (ng/g) of POPs in human milk and blood, beef meat, water, sediments and crops from Ghana

	Meat 2006	Blood 2001	Milk 2001	Water 2001	Sediments 2001	Crops 2001
DDT	489.355					
DDE	40.34	380	490	0	0.46	0
DDD	0	0	0	0	0	0
Aldrin	4.165	0	0	0	0	0
Dieldrin	14.32	0	0	0	0	0
Heptachlor					0.63	1.65
HCB	0	30	40	0	0.9	0

Source: Amoh et al. (2006); Ntow (2001)

Table E 72: POPs residues Water, sediments and fish from Ghana (2008)

Pesticides	Water	Sediment	Fish
Aldrin	0	0.065	0.0178
Dieldrin	0	0.072	0.035
DDE	0.061	8.342	5.232
DDT	0.012	4.41	3.645

Source: Ntow et al. (2008)

Table E 73: POPs in water from Senegal in 2003

POPs	Water	Soil
HCB	0.4	1.2
Heptachlor	8.8	1.7
DDT	63.9	24.2
Aldrin	0.5	0.6
Dieldrin	0.1	1.5
Endrin	2.7	0.3
Mirex	2.8	0.3

Source : Manirakiza et al. (2003)

Table E 74: Concentrations (ng/g) of pesticides residues in Soil and water from Mali

POPs	Soil				Water
	Koutiala	Sikasso	Kita	San	Kita/San
Dieldrin	0	0	< QL	< QL	
pp'DDD	0	0	< QL	< QL	< QL
pp'DDE	121	20	< QL	< QL	< QL
DDT	11	0	< QL	< QL	< QL

Source: Dem et al. (2007)

QL = Quantification Limit

Table E 75: POPs residues levels in fish from Burundi (1999)

POPs	<i>B. microlopiis</i>	<i>C. sianenna</i>	<i>O. niloticus</i>	<i>L. stappersii</i>	<i>L. miodon</i>	<i>S. tanganyikae</i>	<i>L. angustifrons</i>	Mean (ng/g)
HCB	19.5	2.4	6.5	3.6	3.5	6.5	2.1	6.3
Heptachlor	0	13.6	0	12.3	2.4	18.2	0	6.6
DDT	196.2	53.2	181.5	91.8	11.6	28.3	13.4	82.3
DDE	589.2	242.6	287.7	70.1	42.5	80.8	70.6	197.6
DDD	123.7	53.6	55.4	20.6	14.2	14.9	11.4	42.0
Aldrin	0	42.5	9.5	0	0	0	3.5	7.9
Dieldrin	0	6.1	0	0	0	0	10.2	2.3
Endrin	14.9	5.1	15.4	1.3	0	2.5	3.5	6.1
Mirex	54.8	26.5	16.6	132	0	3.1	3.5	33.8

Table E 76: POPs in fish from Nigeria (2007)

POPs	Levels (µg/g)
DDT	0.06
DDE	0.04
DDD	0.03
Aldrin	0.03

Source: Ize-Iyamu et al. (2007)

Table E 77: POPs in fish from Tanzania (2002)

Pesticides	Samples								Means
	1	2	3	3	3	3	3	3	
DDT	3.7	4.4	3.4	1.1	1.8	1.6	2.6	2.7	2.7
DDE	11.4	6.2	42.6	3.9	7.2	3.1	18.7	2.5	12.0
DDD	5.3	2	7	2.5	4.2	1.9	9.5	11.5	5.5
Dieldrin	0	0	2.7	0	0	0	0	1.2	0.5

Source : Mwevura et al. (2002)

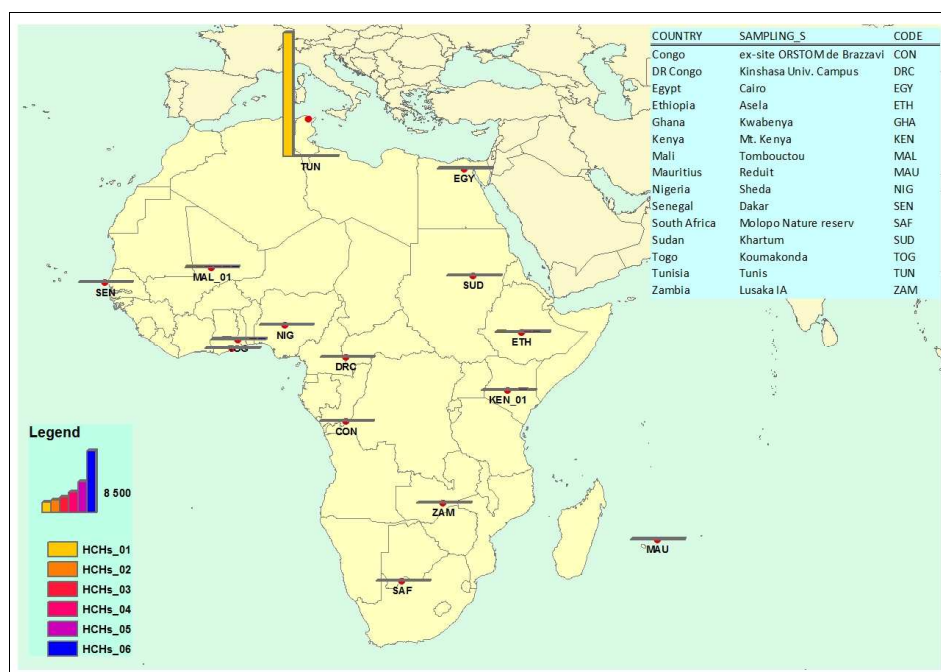


Figure E 1: HCH levels (sum of α , β , γ , δ -HCH) in the ambient air (PAS, ng filter⁻¹) in Africa, January-July, 2008

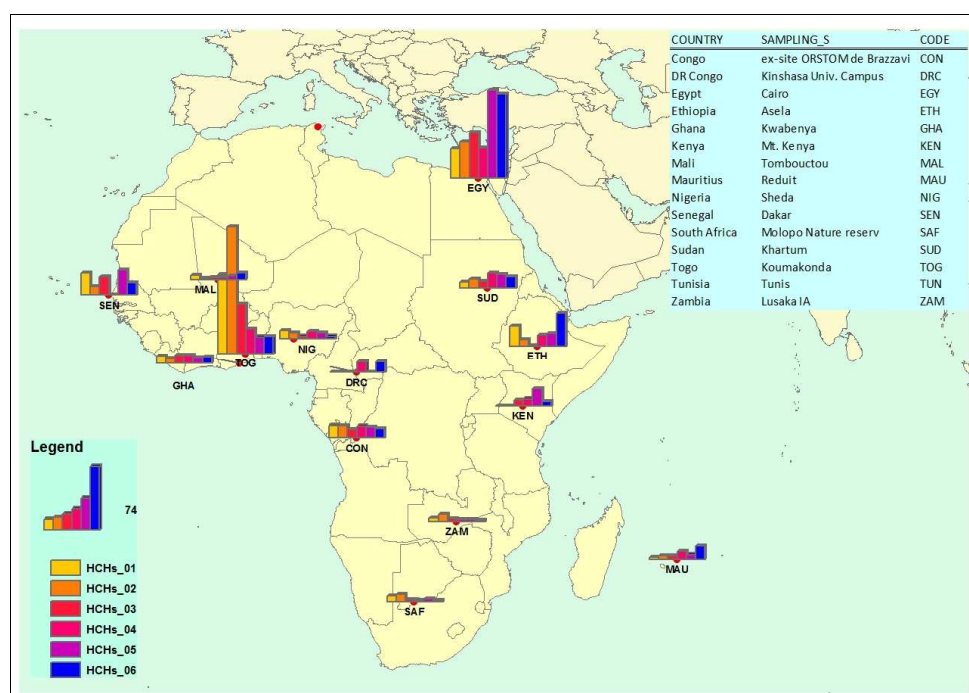


Figure E 2: HCH levels (sum of α , β , γ , δ -HCH) in the ambient air (PAS, ng filter⁻¹) in Africa (two sites excluded), January-July, 2008

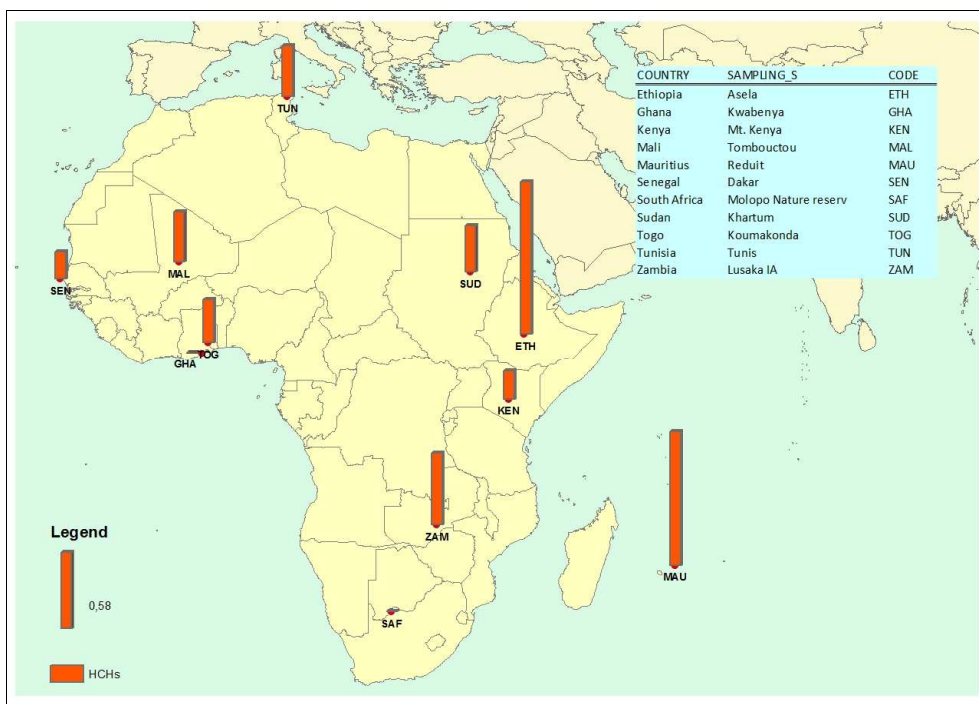


Figure E 3: HCH levels (sum of α , β , γ , δ -HCH) in soil (ng g^{-1}) in Africa, 2008

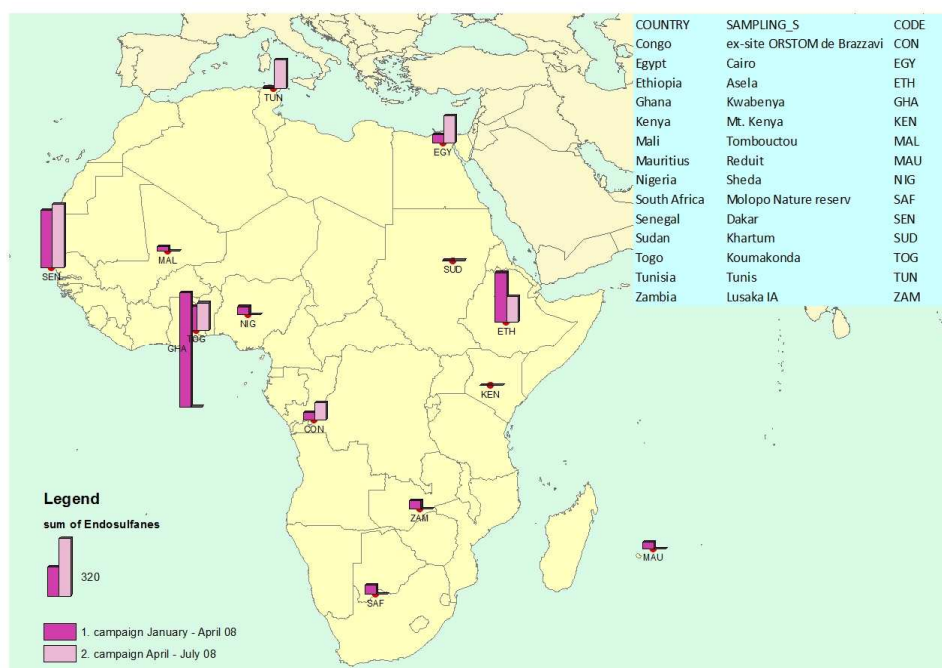


Figure E 4: Endosulfan levels (sum of Endosulfan I and II) in the ambient air ($\text{PAS, ng filter}^{-1}$) in Africa, January-July, 2008.

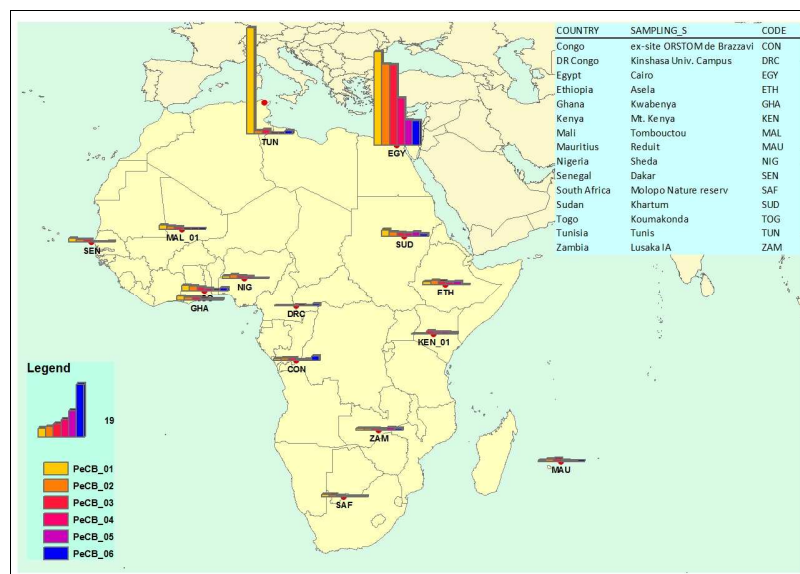


Figure E 5: PeCB levels in the ambient air (PAS, ng filter⁻¹) in Africa, January-July, 2008

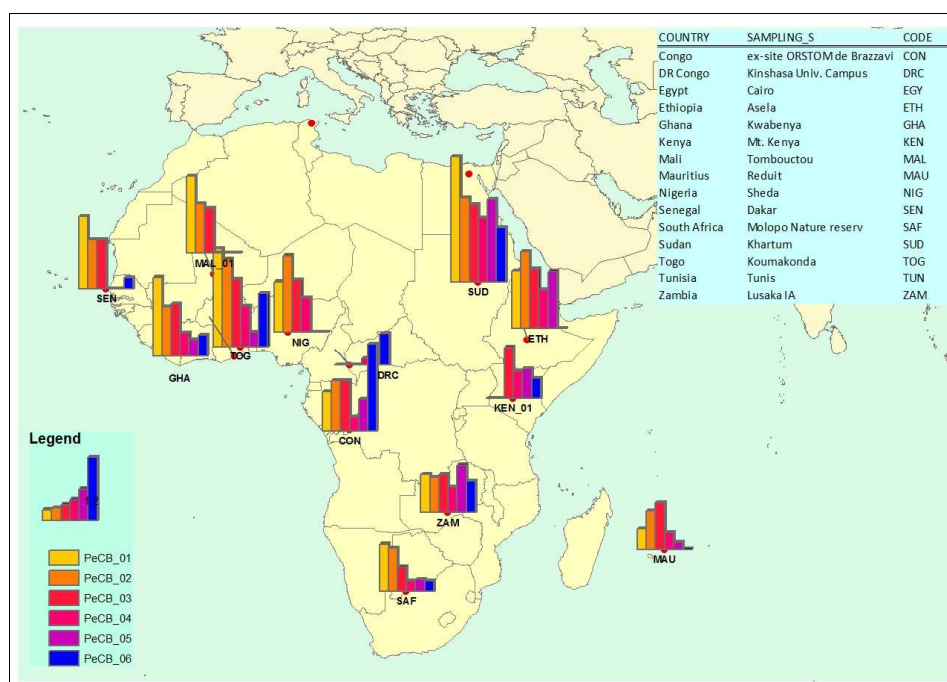


Figure E 6: PeCB levels in the ambient air (PAS, ng filter⁻¹) in Africa (Egypt and Tunisia excluded), January-July, 2008

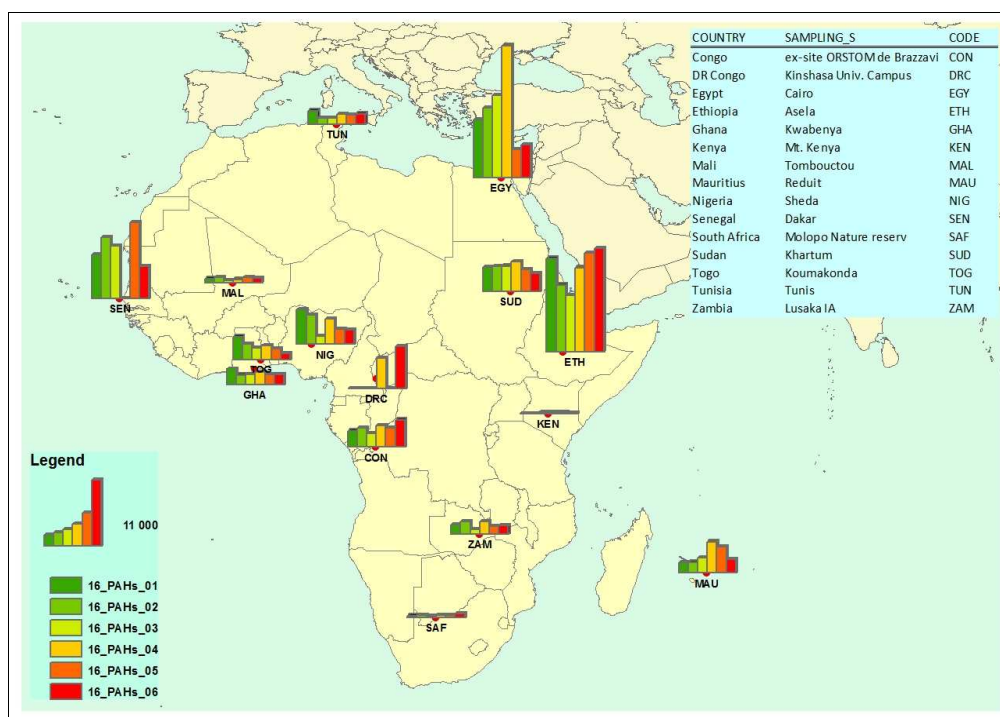


Figure E 7: PAH levels (sum of 16 US EPA PAHs) in the ambient air (PAS, ng filter⁻¹) in Africa, January-July, 2008

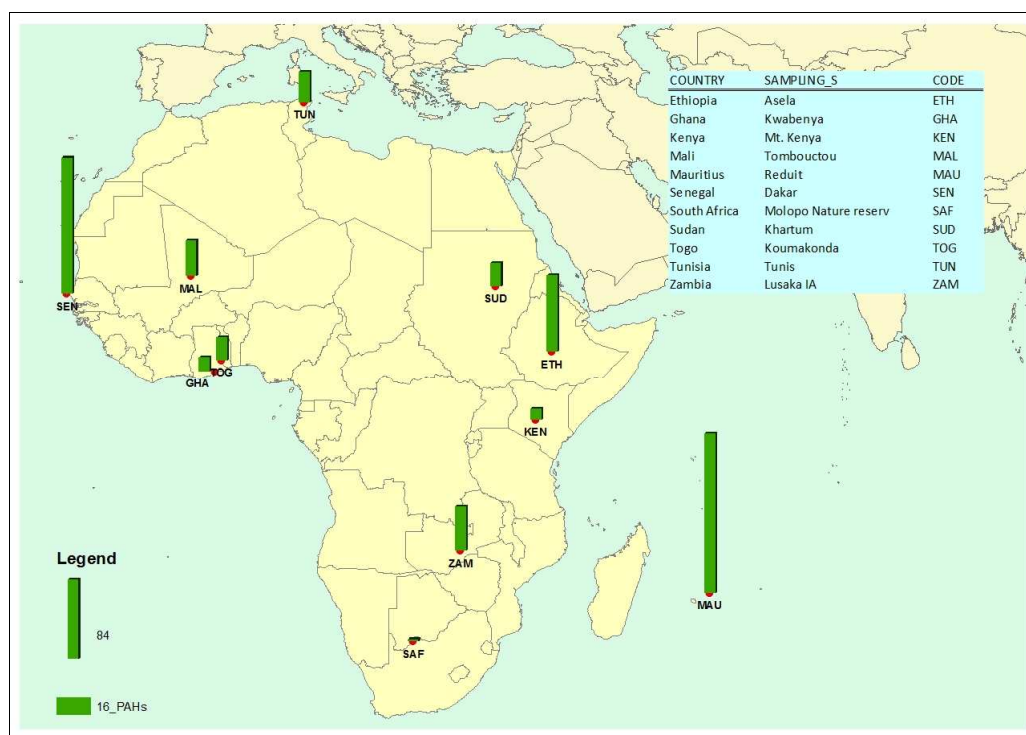


Figure E 8: PAH levels (sum of 16 US EPA PAHs) in soil (ng g⁻¹) in Africa, 2008

AFRICA 2008, KENYA

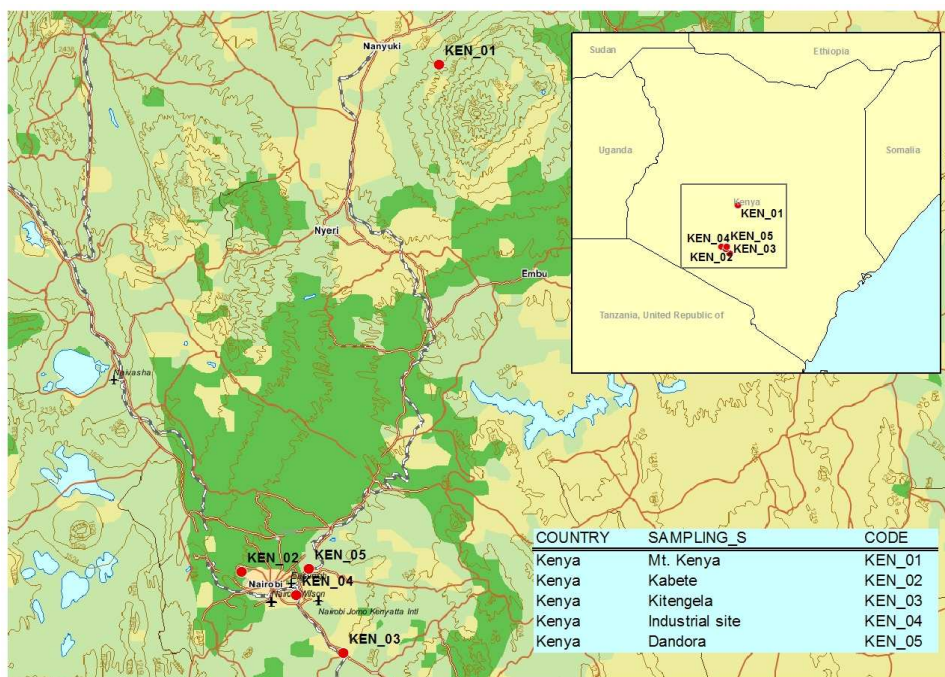


Figure E 9: Sampling sites in Kenya, 2008

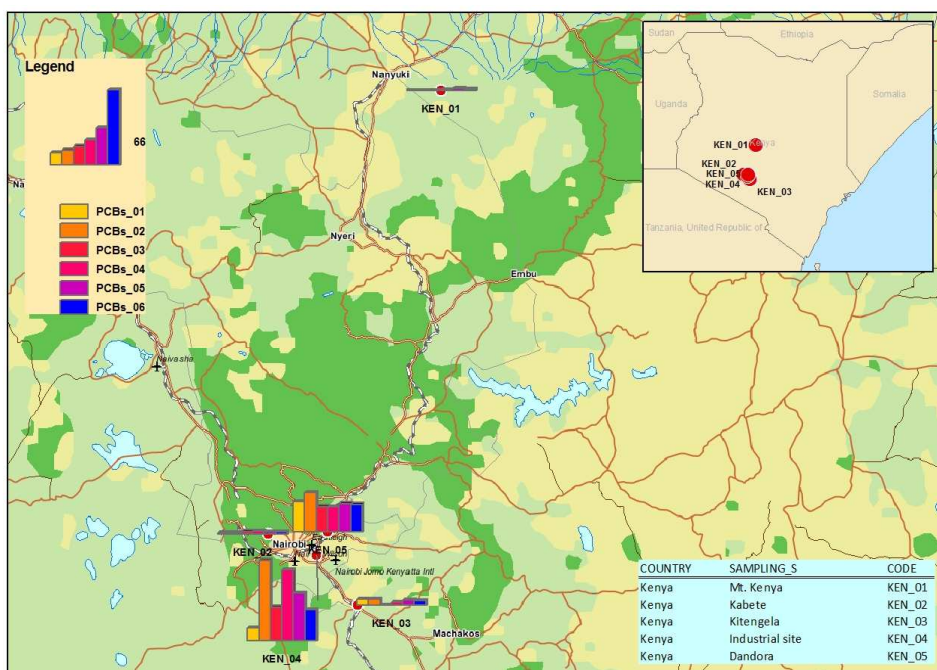


Figure E 10: PCB levels (7 indicator congeners) in the ambient air (PAS, ng filter⁻¹) in Kenya, January-July, 2008

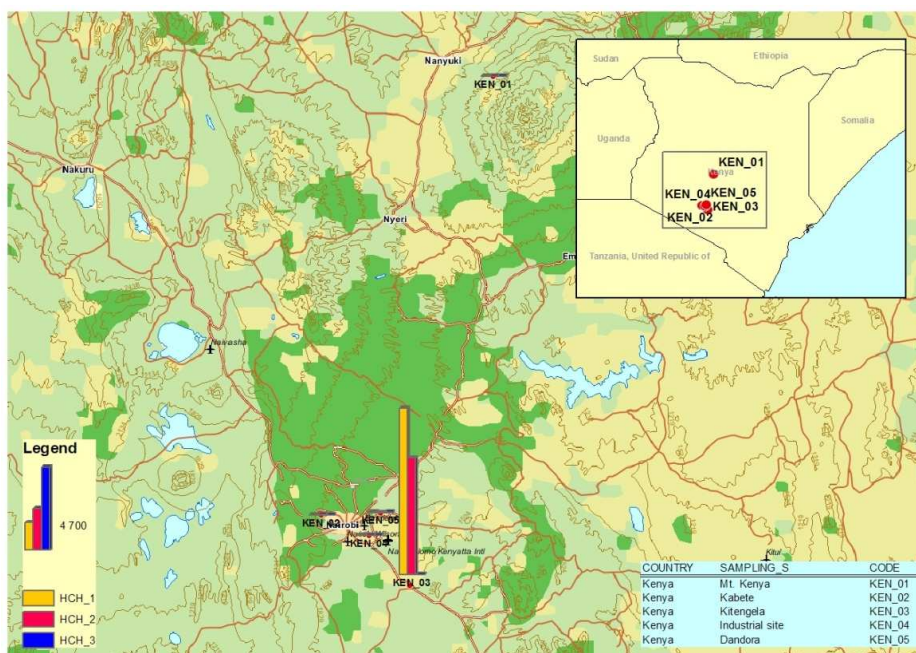


Figure E 11: HCH levels (sum of α , β , γ , δ -HCH) in the ambient air (PAS, ng filter⁻¹) in Kenya, January-July, 2008

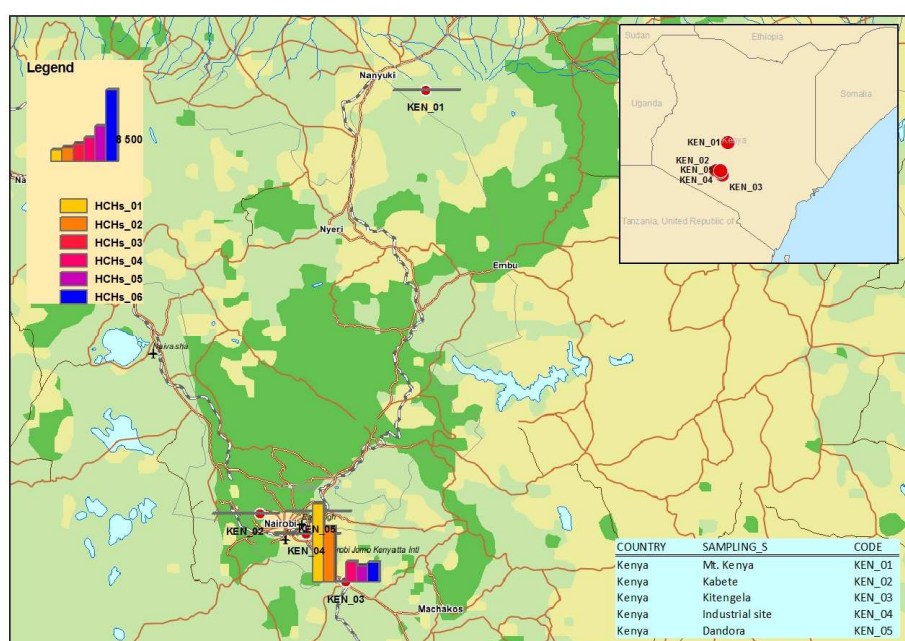


Figure E 12: HCH levels (sum of α , β , γ , δ -HCH) in the ambient air (PAS, ng filter⁻¹) in Kenya (one site excluded), January-July, 2008

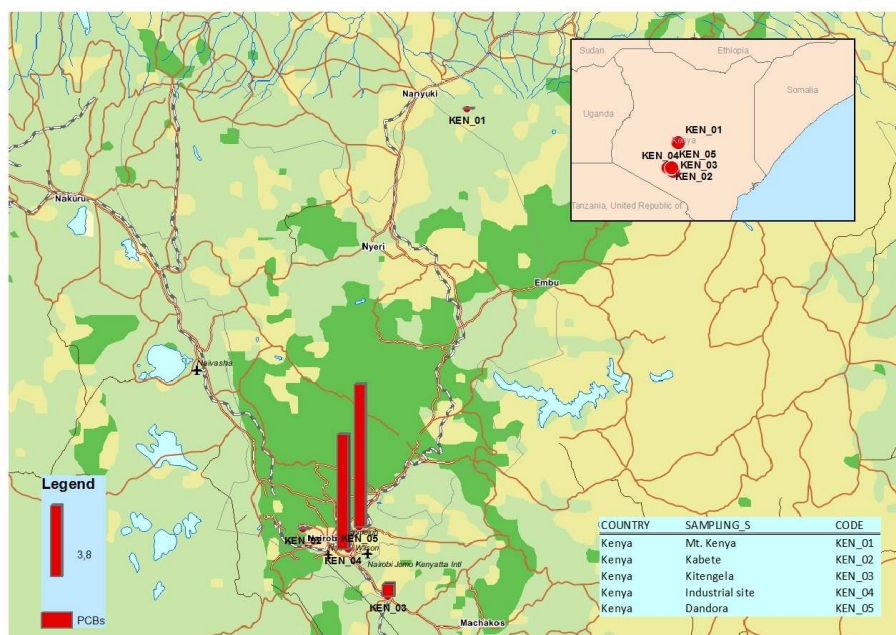


Figure E 13: PCB levels (7 indicator congeners) in soil (ng g^{-1}) in Kenya, 2008

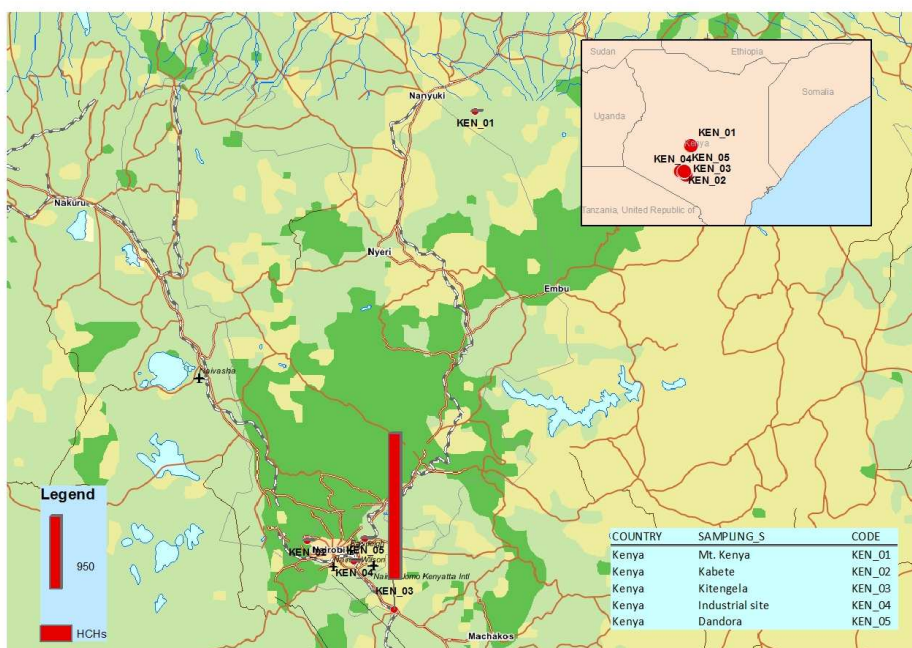


Figure E 14 : HCH levels (sum of α , β , γ , δ -HCH) in soil (ng g^{-1}) in Kenya, 2008

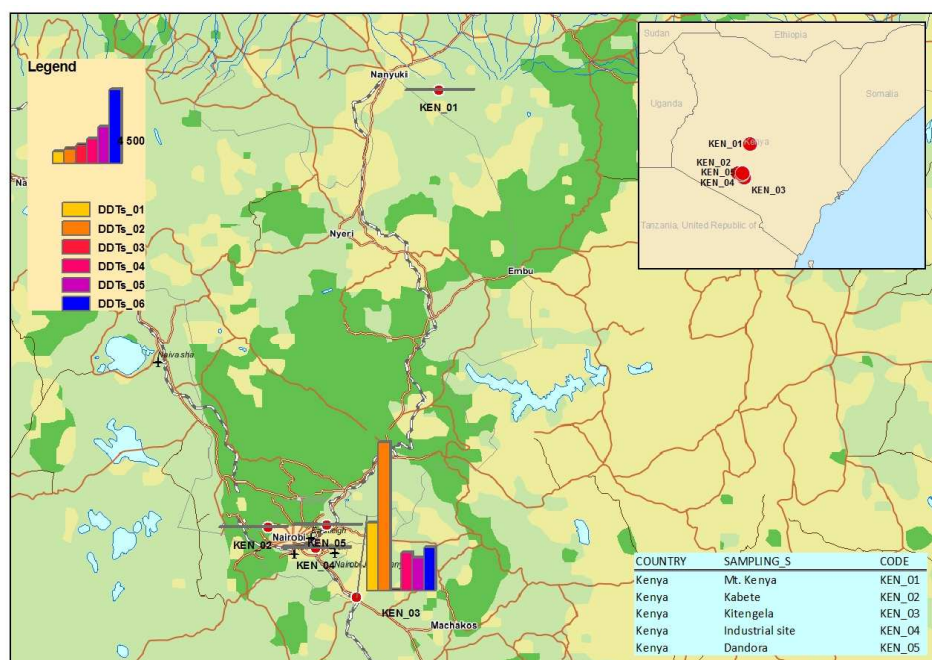


Figure E 15: DDT levels (sum of *o,p'*- and *p,p'*-DDT, DDE, DDD) in the ambient air (PAS, ng filter⁻¹) in Kenya, January-July, 2008

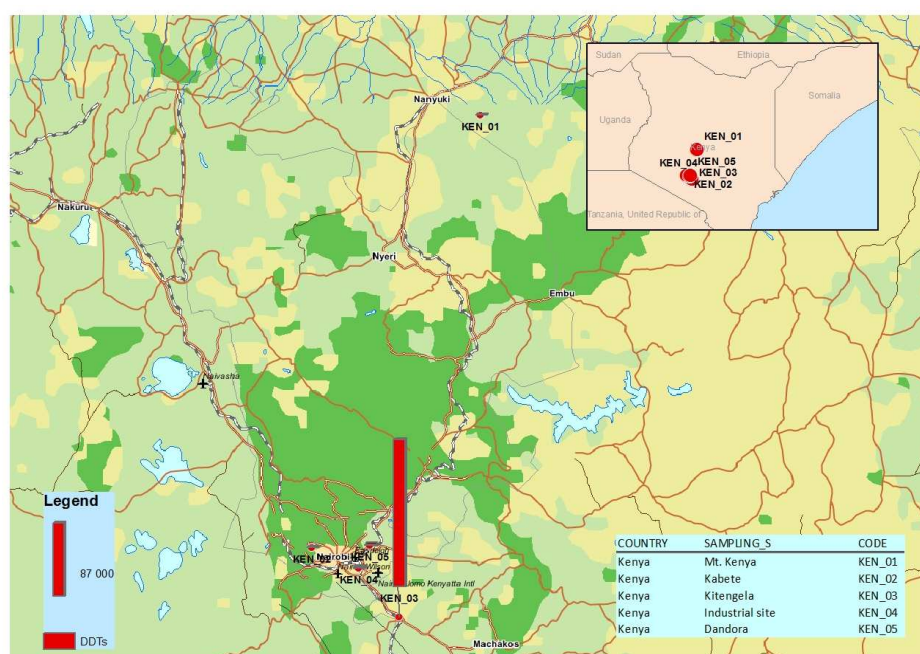


Figure E 16: DDT levels (sum of *o,p'*- and *p,p'*-DDT, DDE, DDD) in the ambient air (PAS, ng filter⁻¹) in Kenya (one site excluded), January-July, 2008

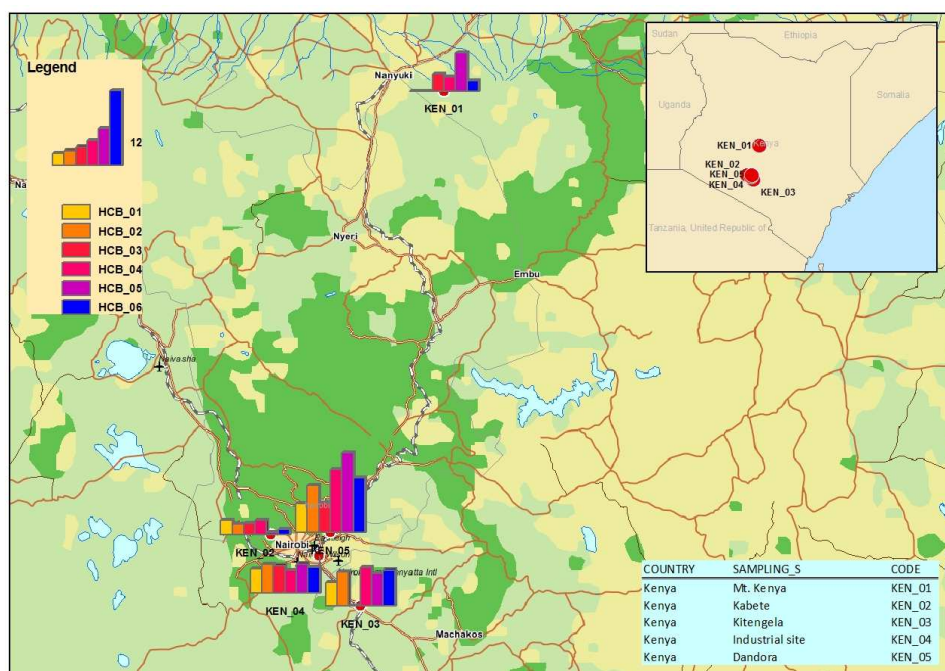


Figure E 17: HCB levels in the ambient air (PAS, ng filter⁻¹) in Kenya, January-July, 2008

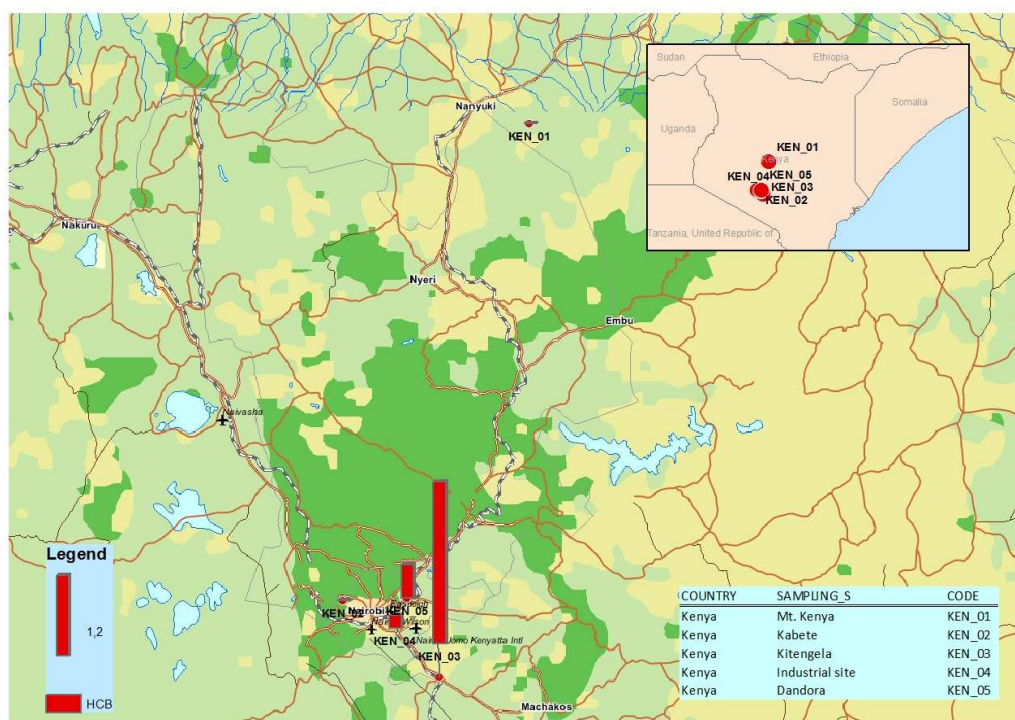


Figure E 18: HCB levels in soil (ng g⁻¹) in Kenya, 2008

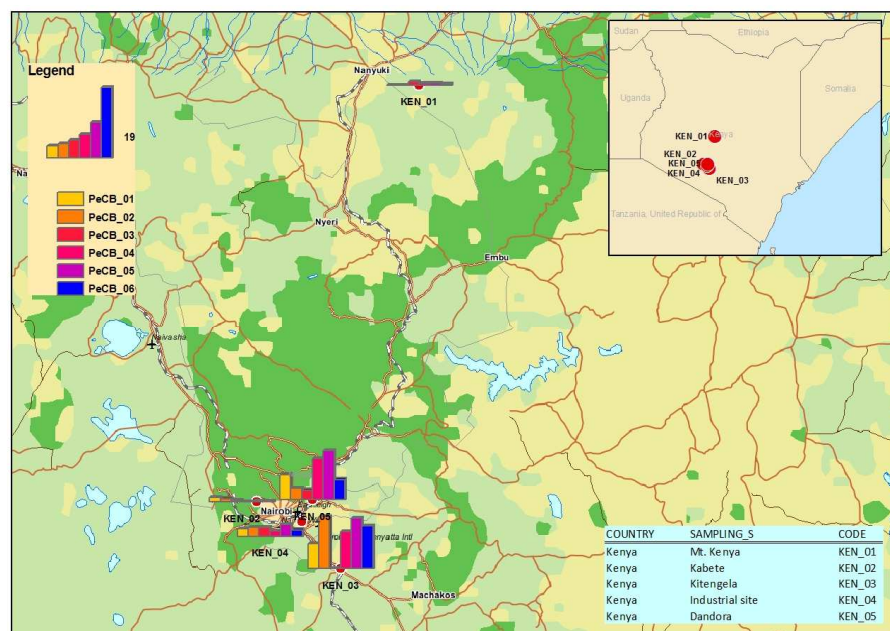


Figure E 19: PeCB levels in the ambient air (PAS, ng filter⁻¹) in Kenya, January-July, 2008

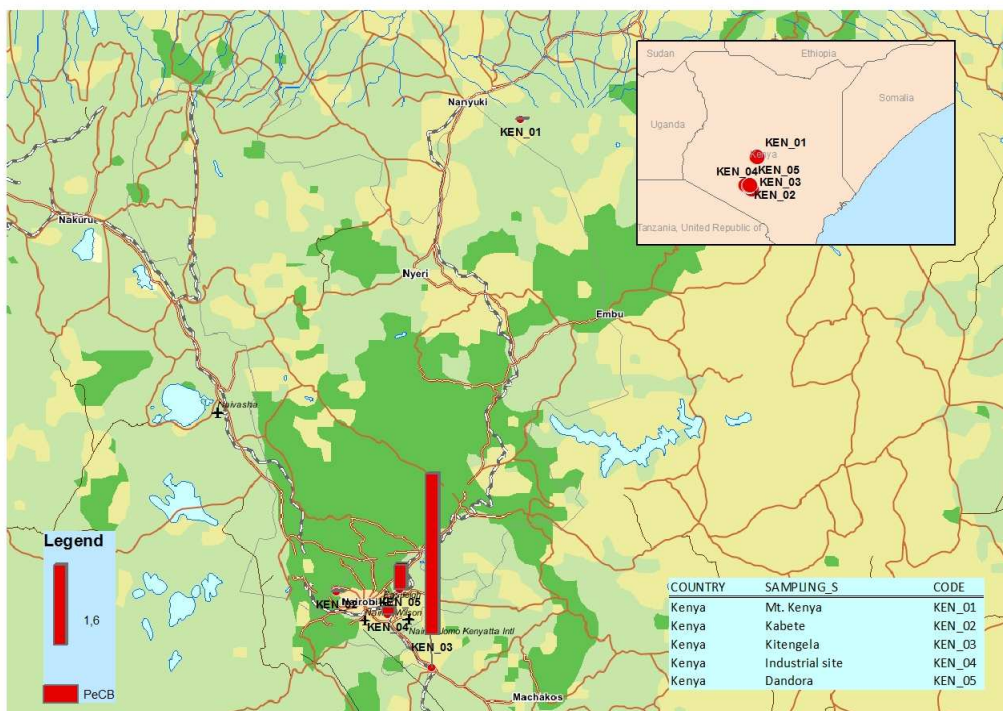


Figure E 20: PeCB levels in soil (ng g⁻¹) in Kenya, 2008

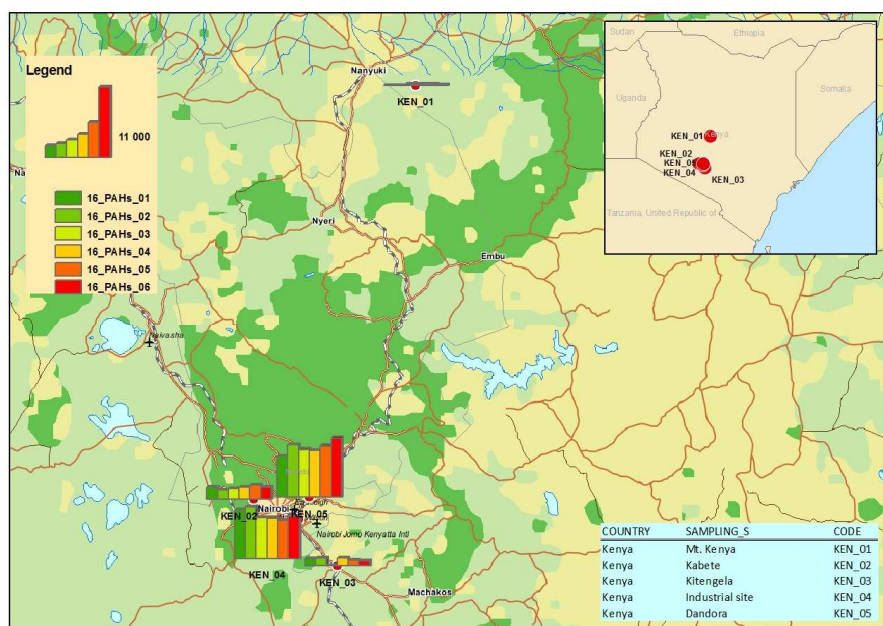


Figure E 21: PAH levels (sum of 16 US EPA PAHs) in the ambient air (PAS, ng filter⁻¹) in Africa, January-July, 2008

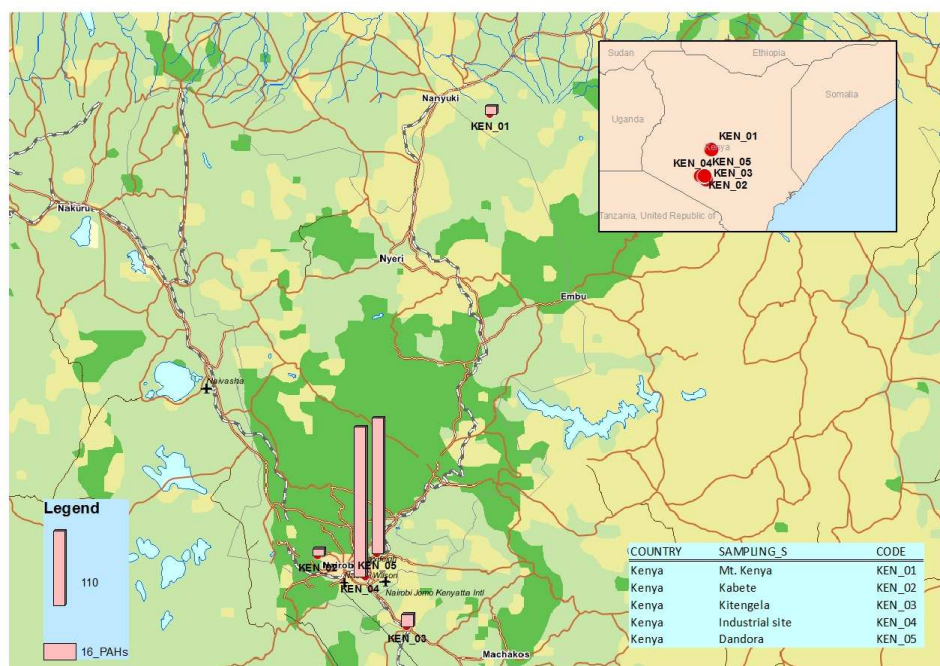


Figure E 22: PAH levels (sum of 16 US EPA PAHs) in soil (ng g⁻¹) in Kenya, 2008

AFRICA 2008, MALI

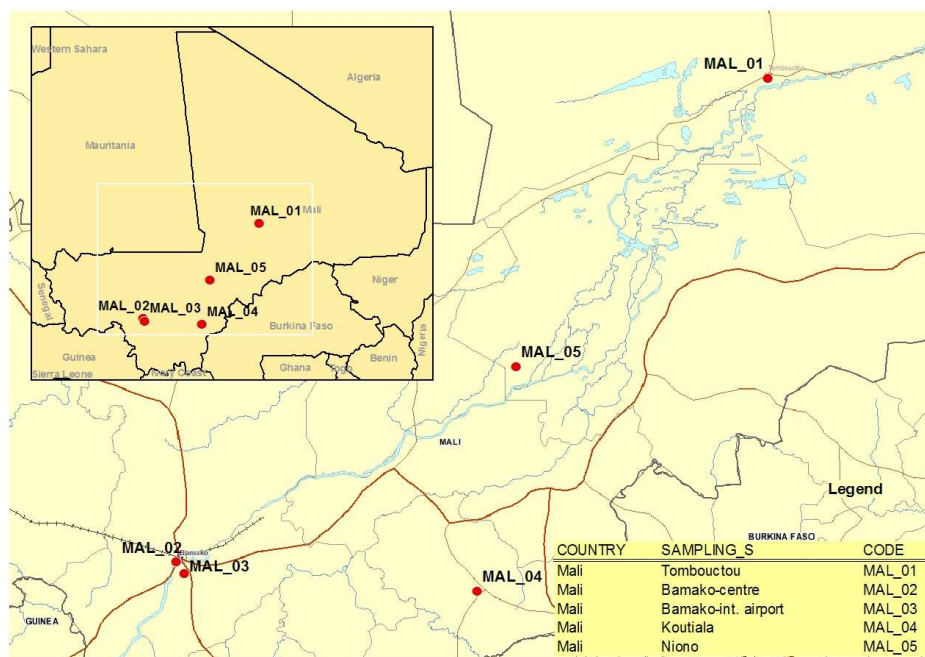


Figure E 23: Sampling sites in Mali, 2008

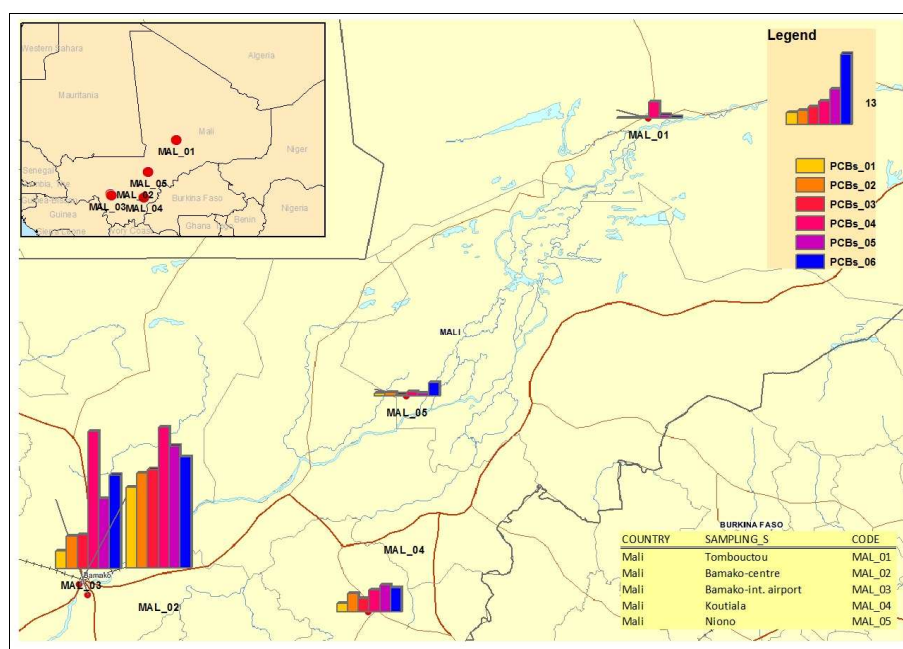


Figure E 24: PCB levels (7 indicator congeners) in the ambient air (PAS, ng filter⁻¹) in Mali, January-July, 2008

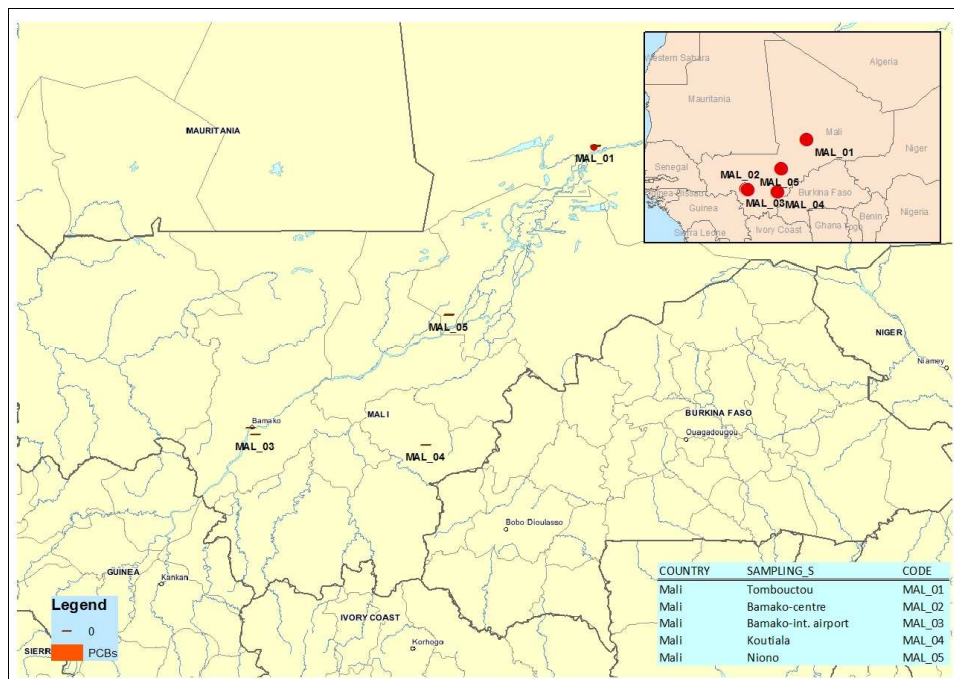


Figure E 25: PCB levels (7 indicator congeners) in soil (ng g^{-1}) in Mali, 2008

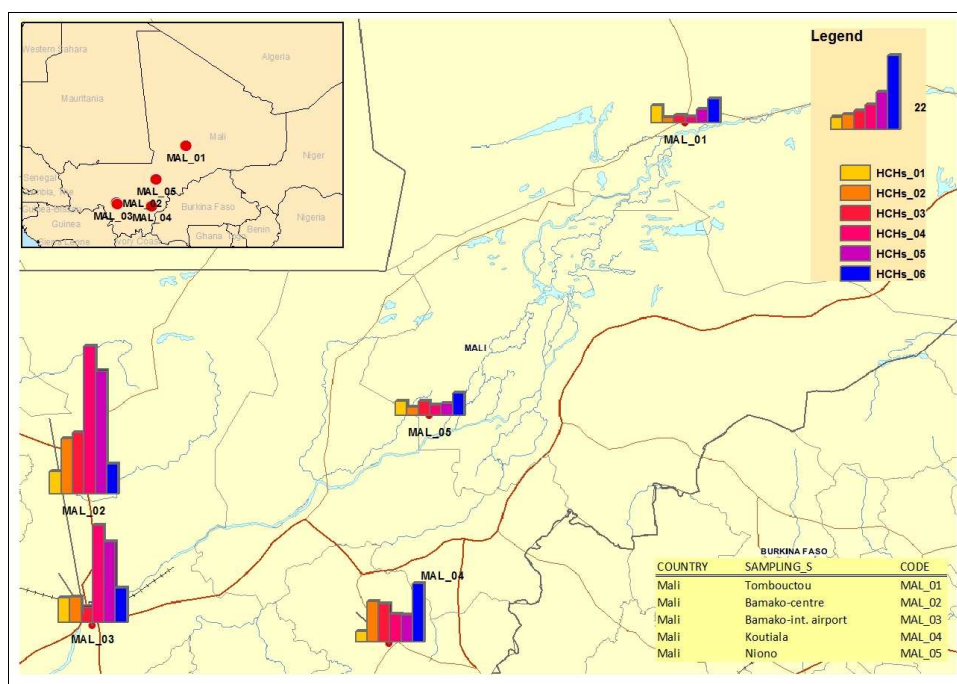


Figure E 26: HCH levels (sum of α , β , γ , δ -HCH) in the ambient air (PAS, ng filter^{-1}) in Mali, January-July, 2008

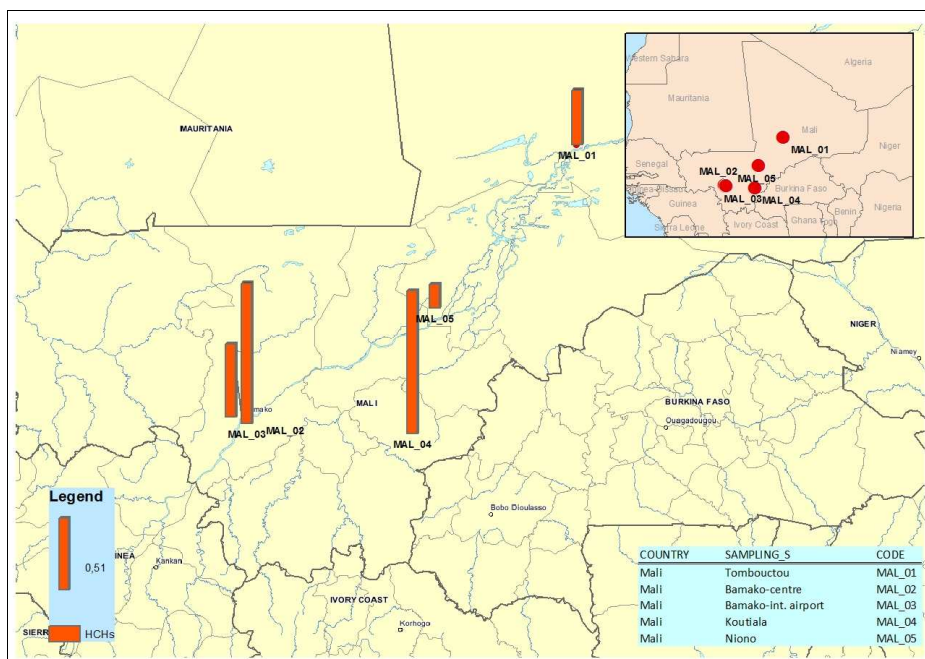


Figure E 27: HCH levels (sum of α , β , γ , δ -HCH) in soil (ng g⁻¹) in Mali, 2008

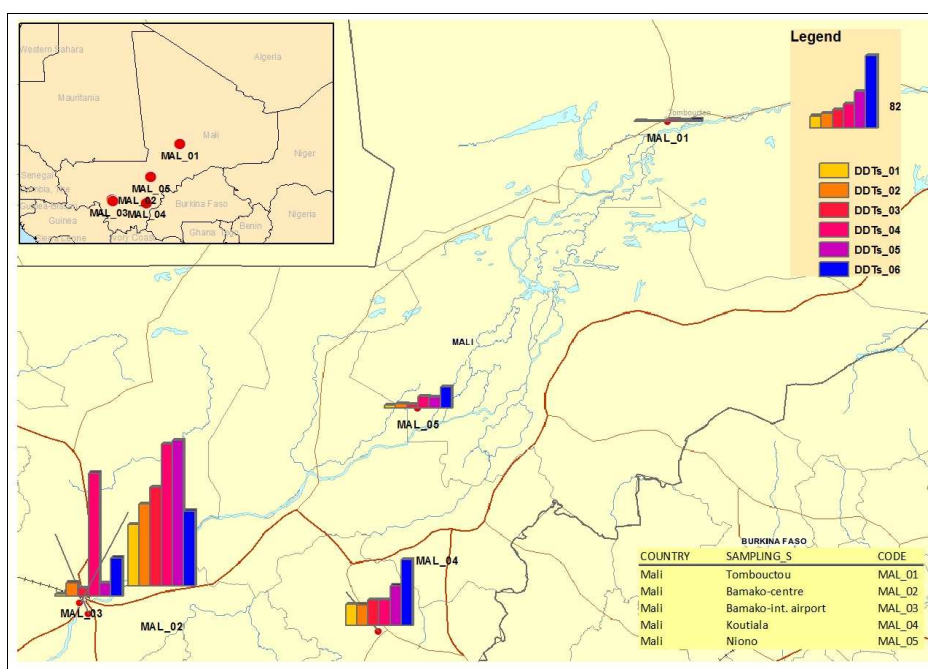


Figure E 28: DDT levels (sum of *o,p'*- and *p,p'*-DDT, DDE, DDD) in the ambient air (PAS, ng filter⁻¹) in Mali, January-July, 2008

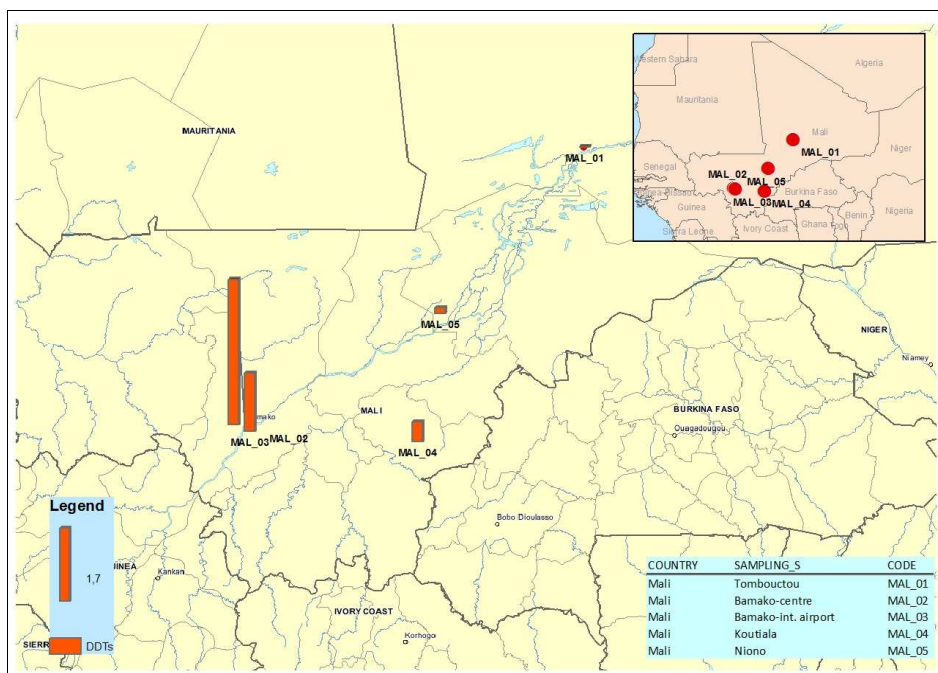


Figure E 29: DDT levels (sum of *o,p'*- and *p,p'*-DDT, DDE, DDD) in the ambient air (PAS, ng filter⁻¹) in Mali (one site ecluded), January-July, 2008

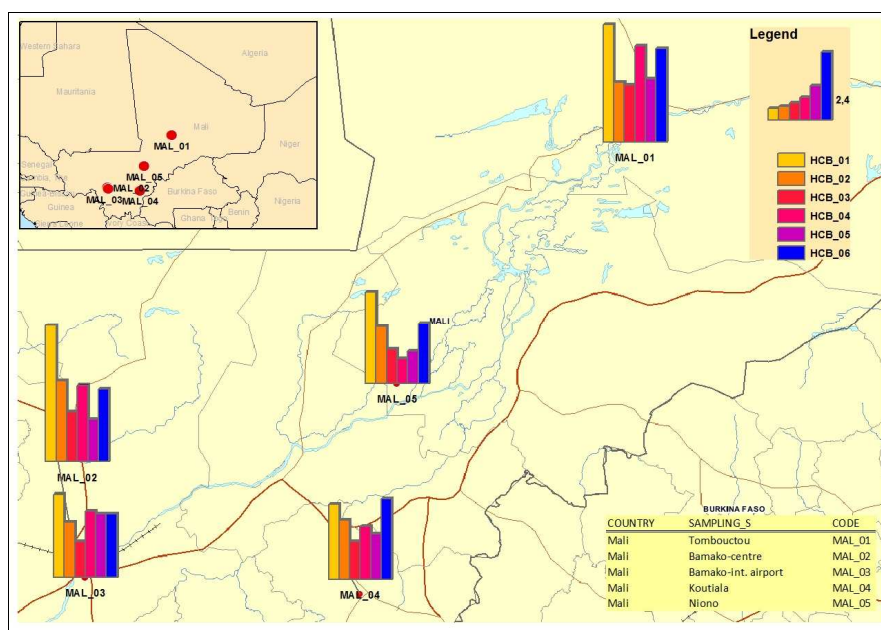


Figure E 30: HCB levels in the ambient air (PAS, ng filter⁻¹) in Mali, January-July, 2008

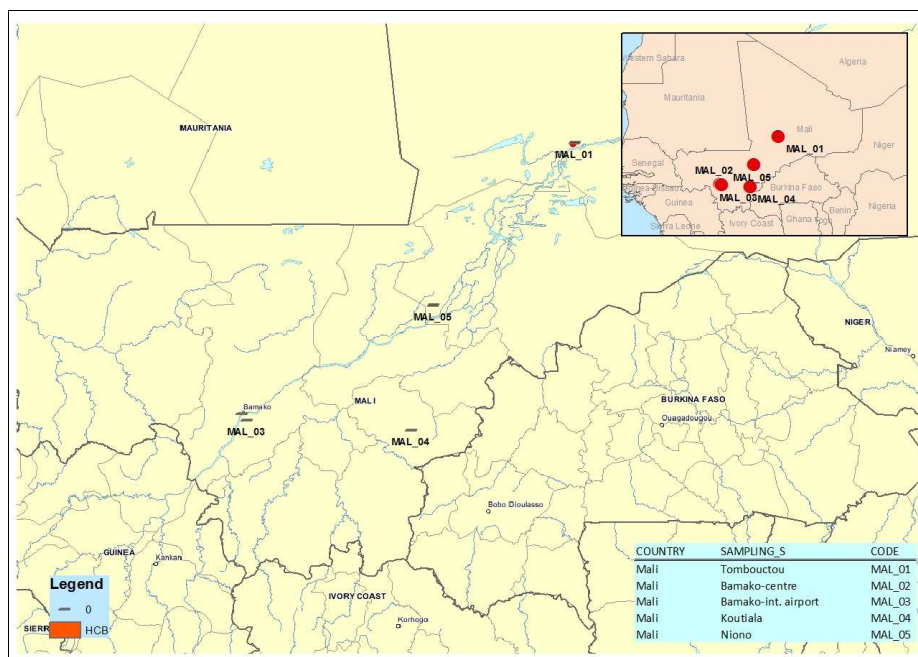


Figure E 31: HCB levels in soil (ng g⁻¹) in Mali, 2008

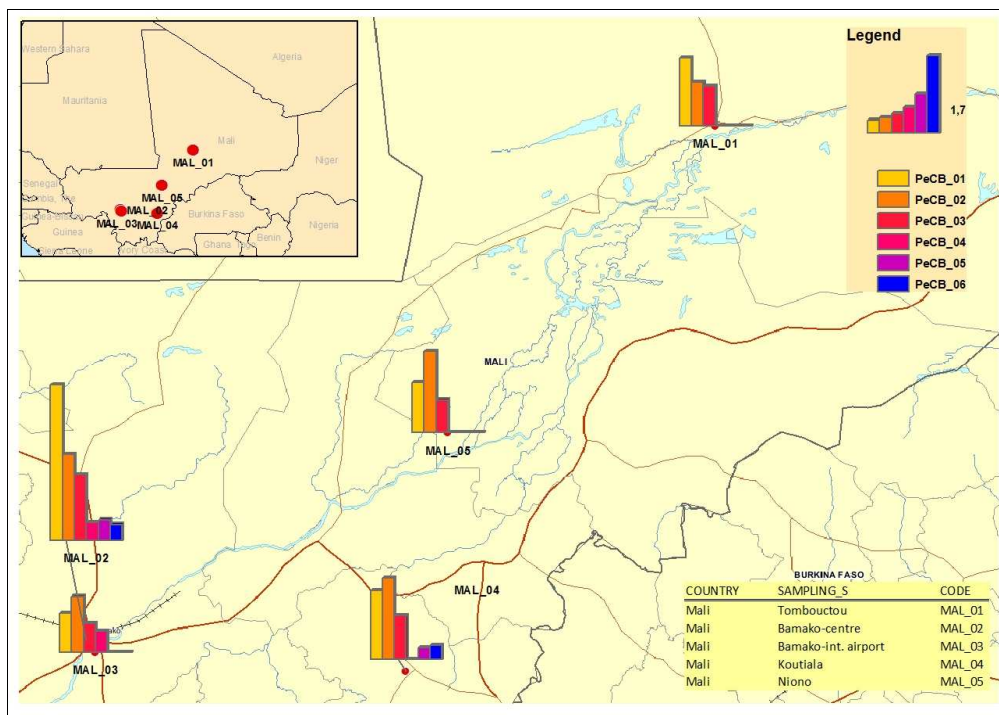


Figure E 32: PeCB levels in the ambient air (PAS, ng filter⁻¹) in Mali, January-July, 2008

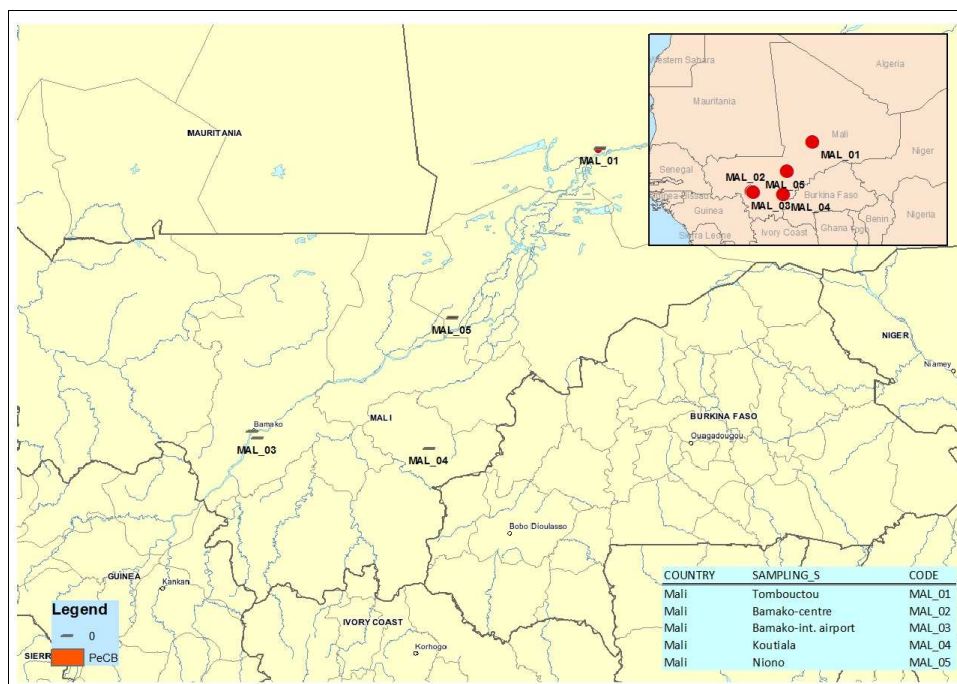


Figure E 33: PeCB levels in soil (ng g⁻¹) in Mali, 2008

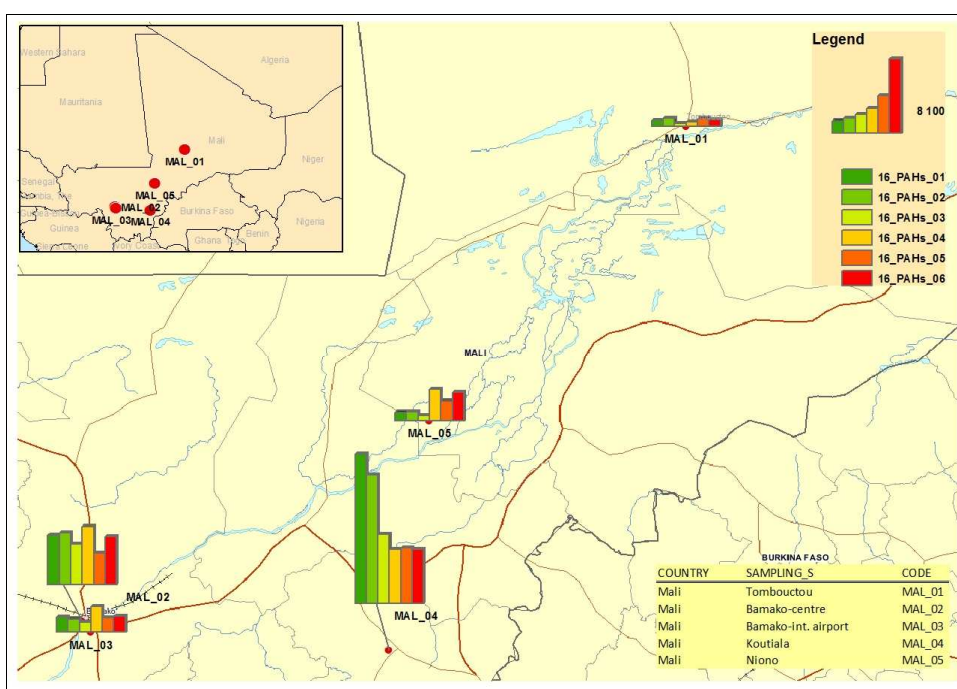


Figure E 34: PAH levels (sum of 16 US EPA PAHs) in the ambient air (PAS, ng filter⁻¹) in Mali, January-July, 2008

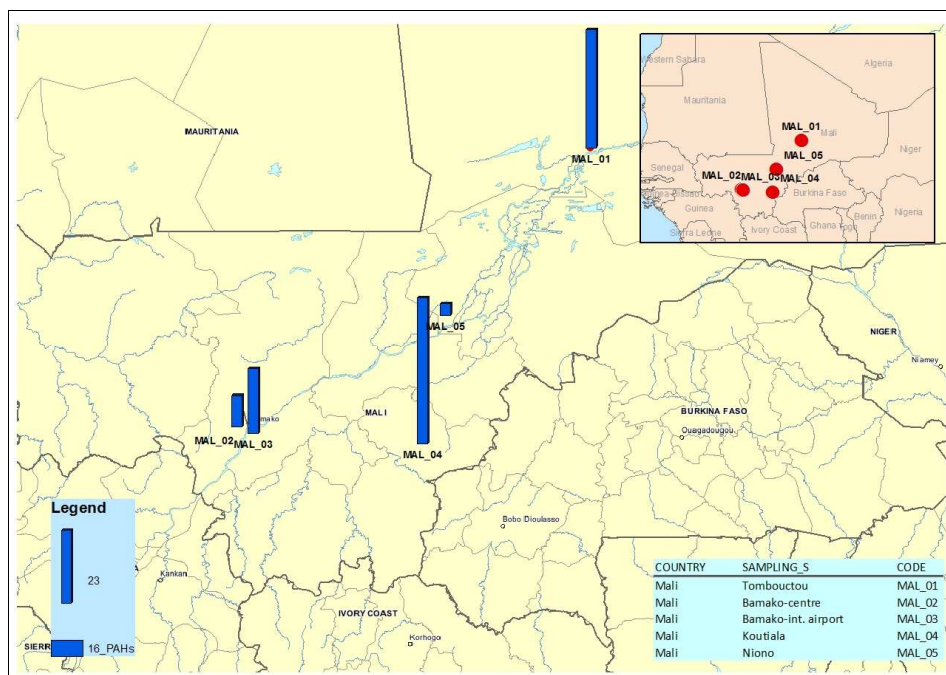


Figure E 35: PAH levels (sum of 16 US EPA PAHs) in soil (ng g⁻¹) in Mali, 2008

TRAJECTORY ANALYSES FOR LONG-RANGE TRANSPORT

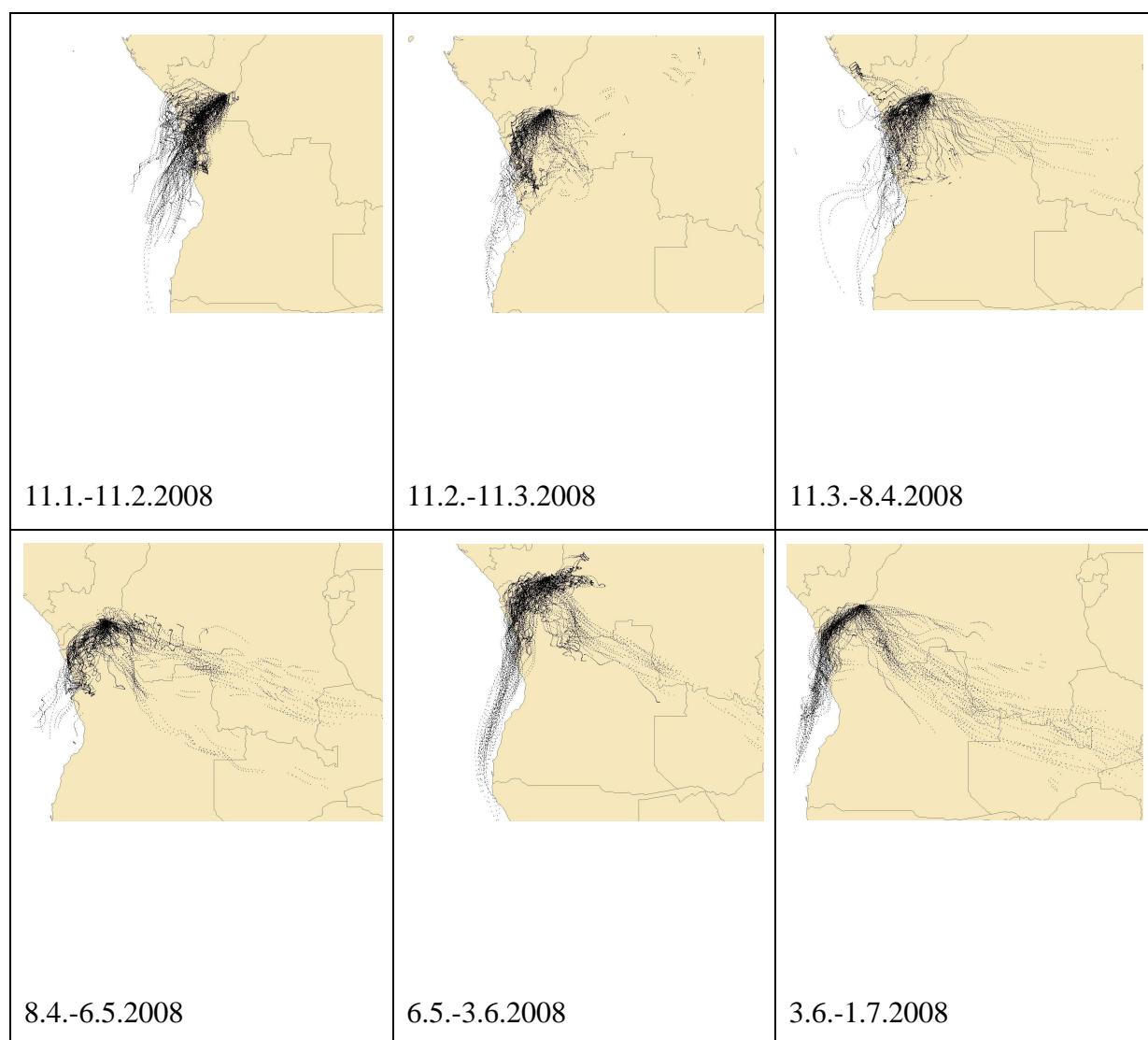


Figure E 36: Variability of the back trajectories for Orstom de Brazzaville (Congo) in a six months sampling period (January – June, 2008)

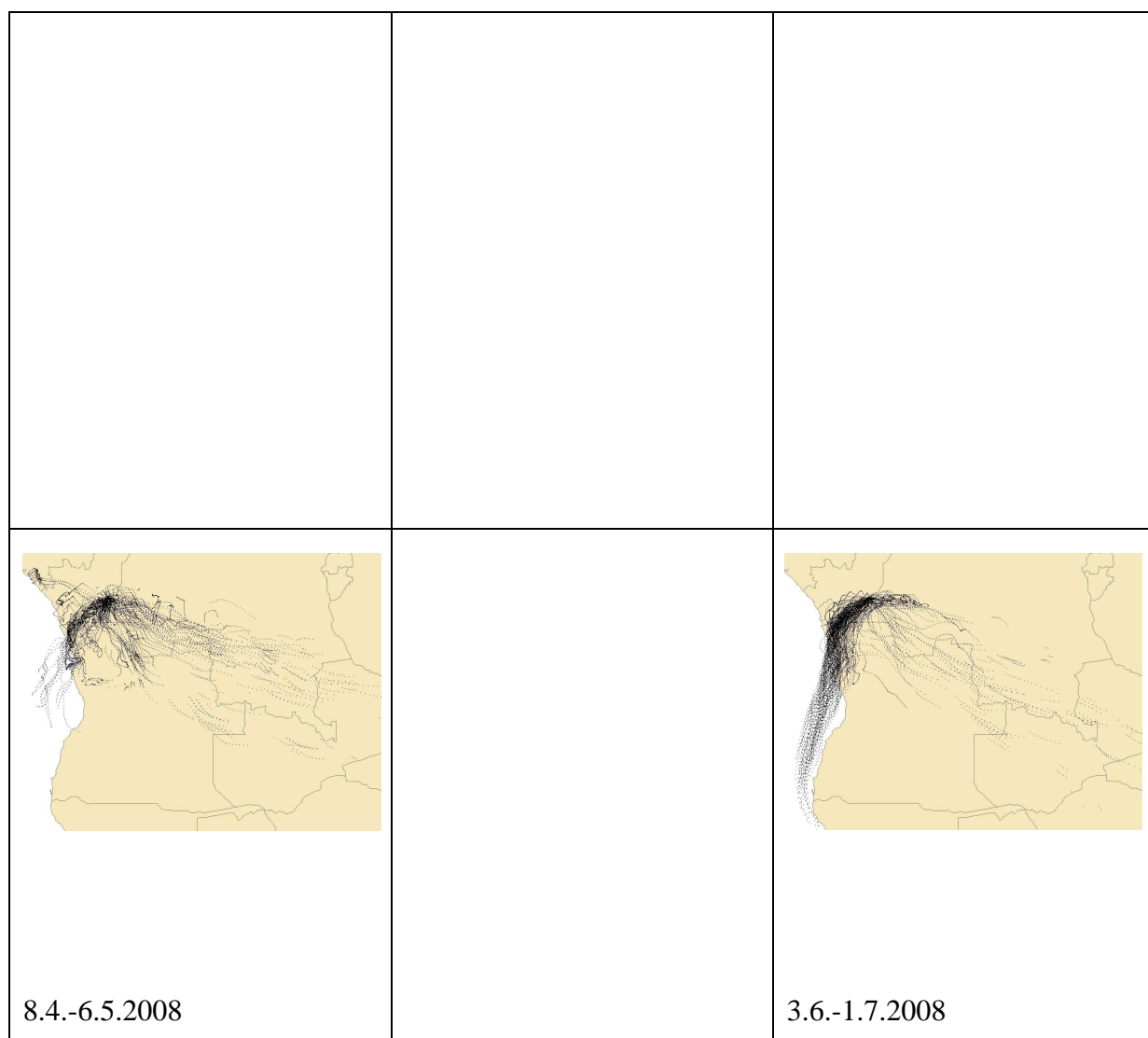


Figure E 37: Variability of the back trajectories for Kinshasa (Democratic Republic of Congo) in a six months sampling period (January – June, 2008).

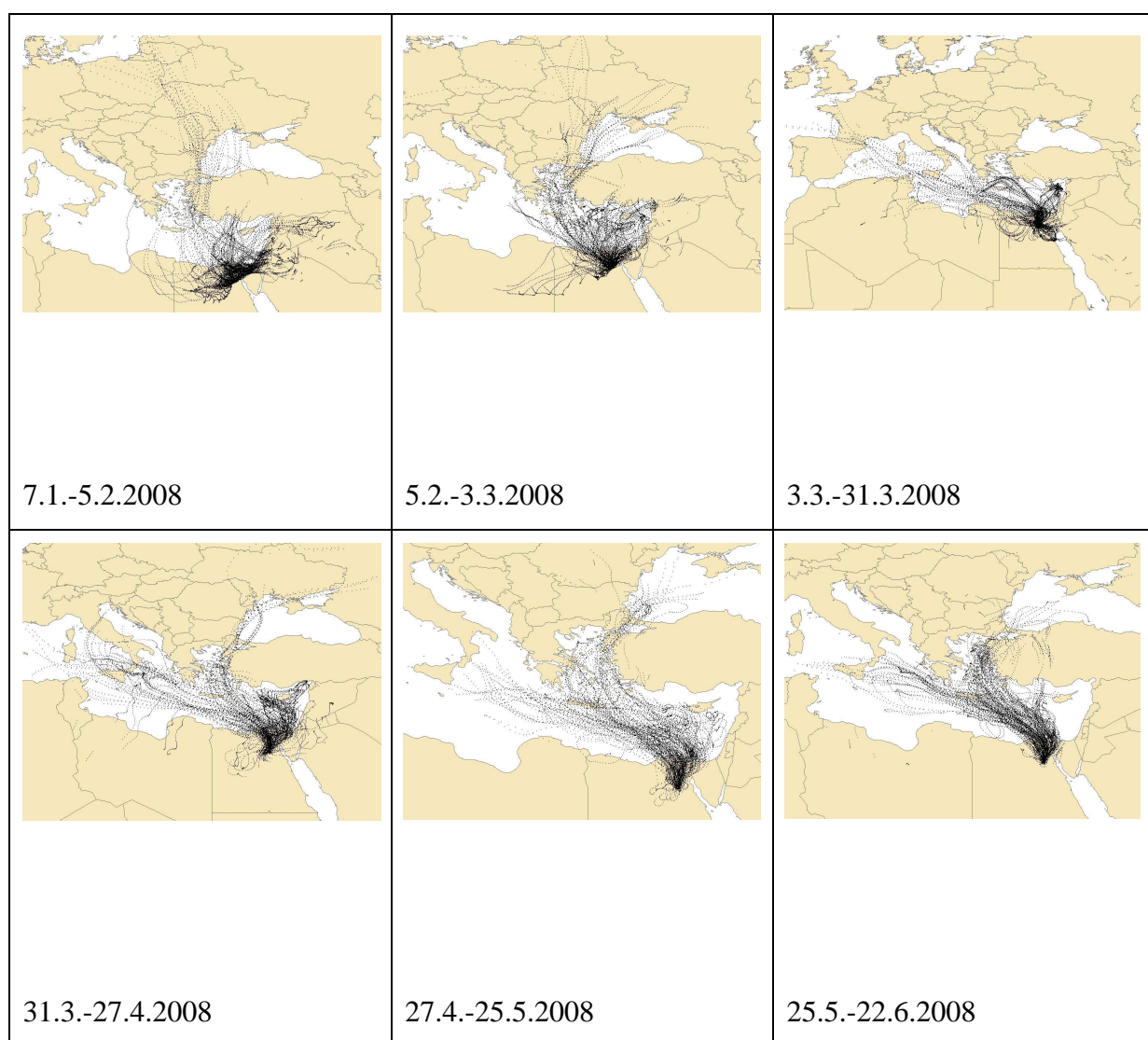


Figure E 38: Variability of the back trajectories for Cairo (Egypt) in a six months sampling period (January – June, 2008)

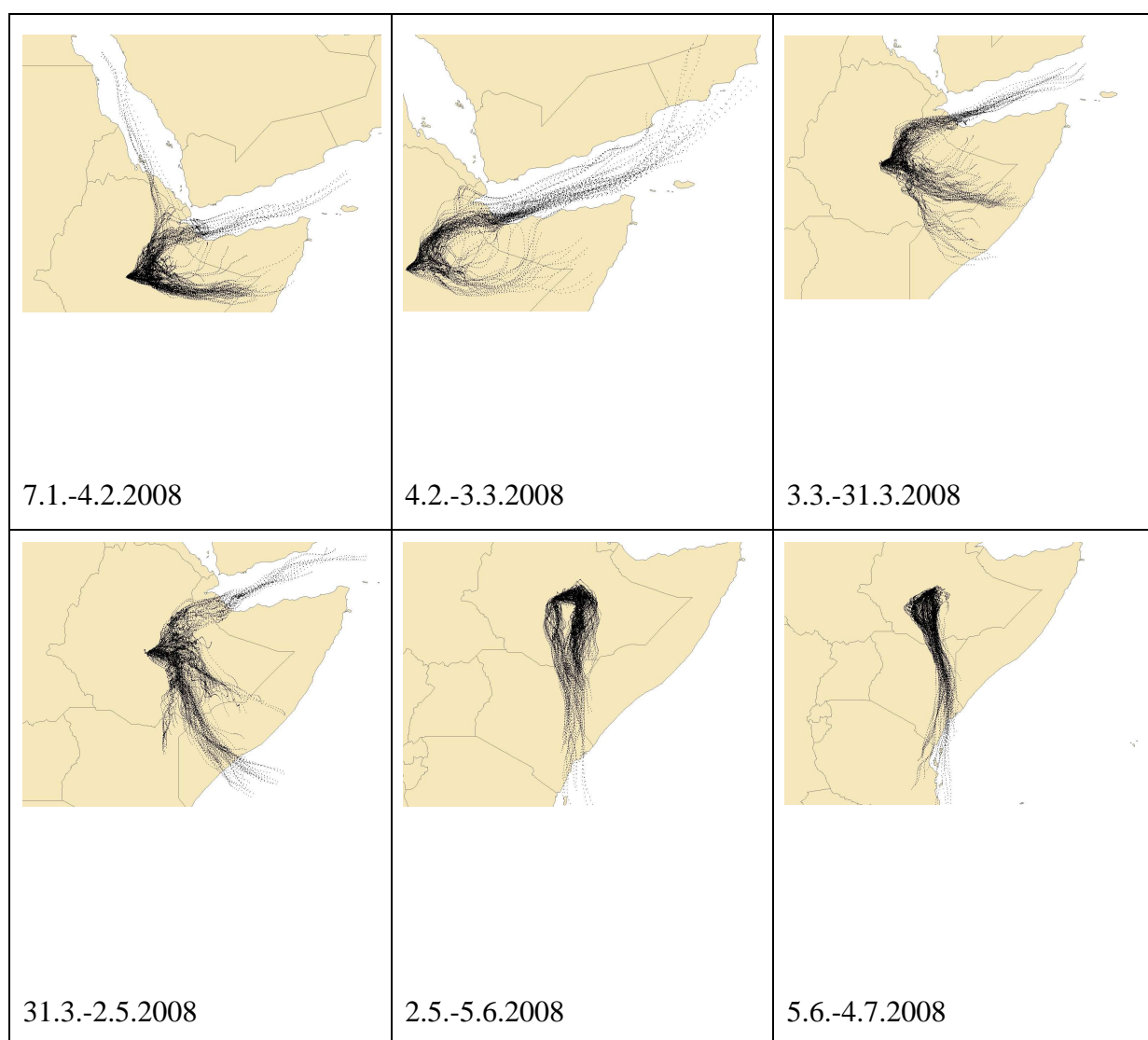


Figure E 39: Variability of the back trajectories for Asala (Ethiopia) in a six months sampling period (January – June, 2008)

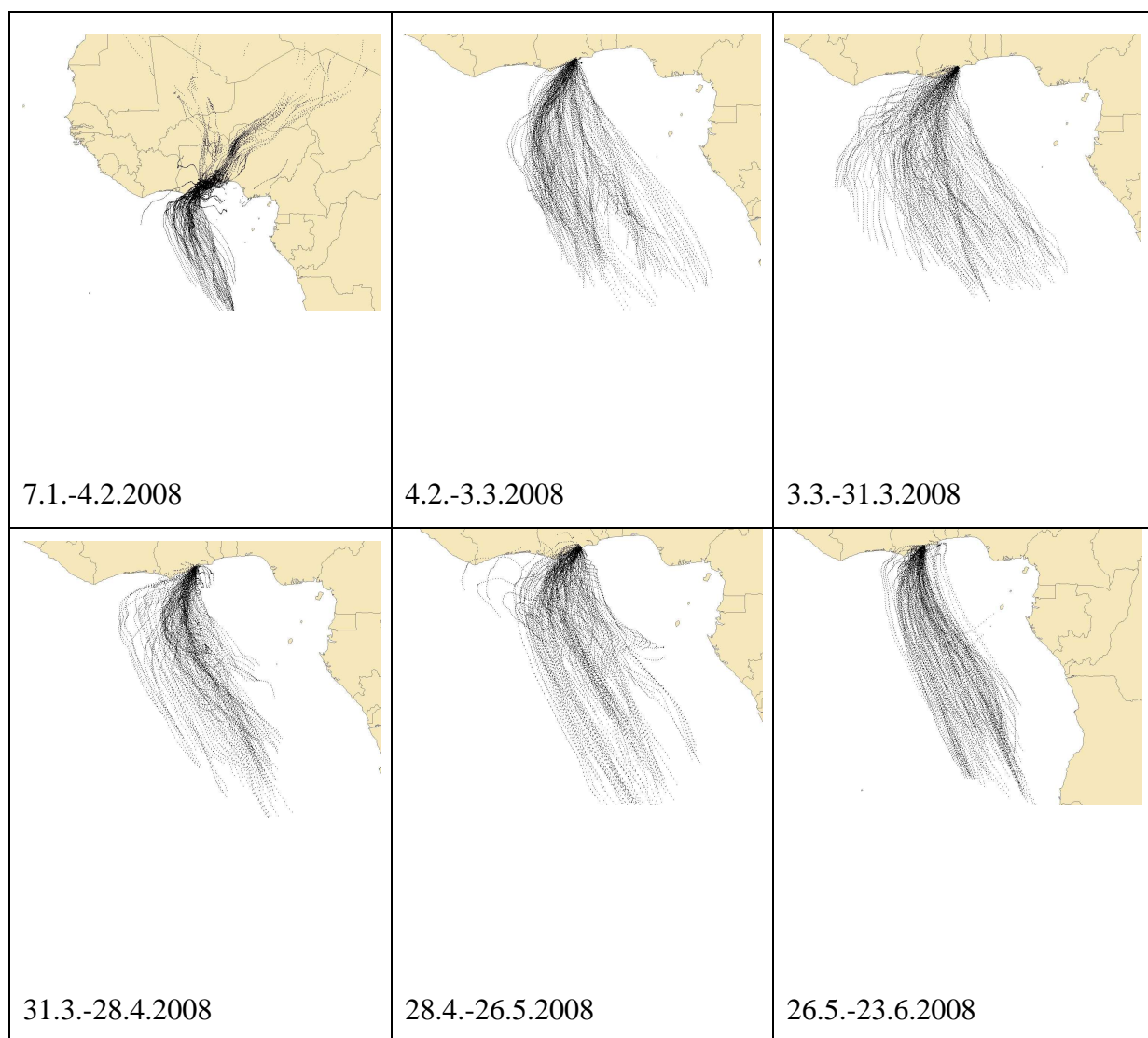


Figure E 40: Variability of the back trajectories for Kwabinya (Ghana) in a six months sampling period (January – June, 2008)

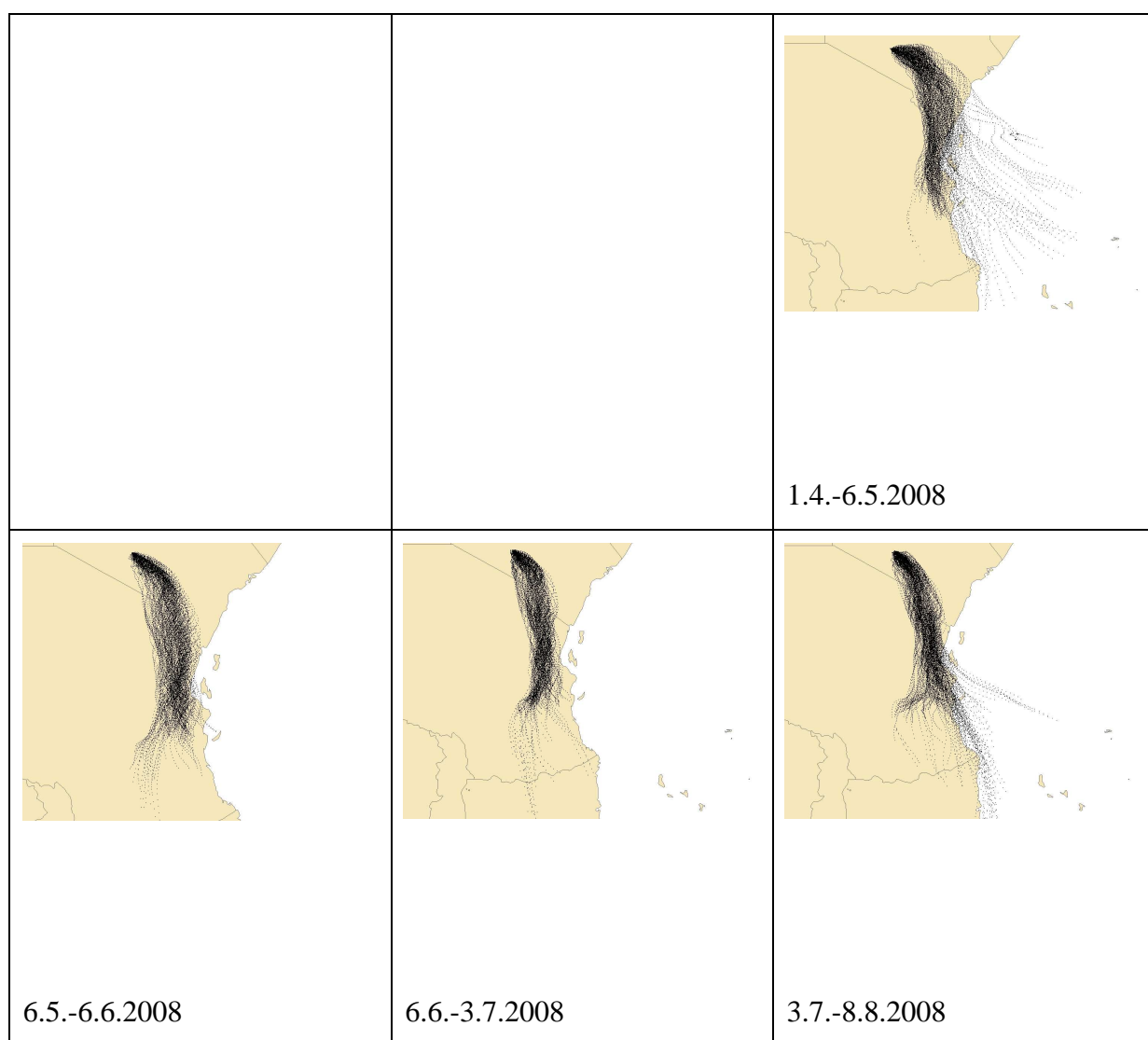


Figure E 41: Variability of the back trajectories for Kabete (Kenya) in a six months sampling period (March – August, 2008)

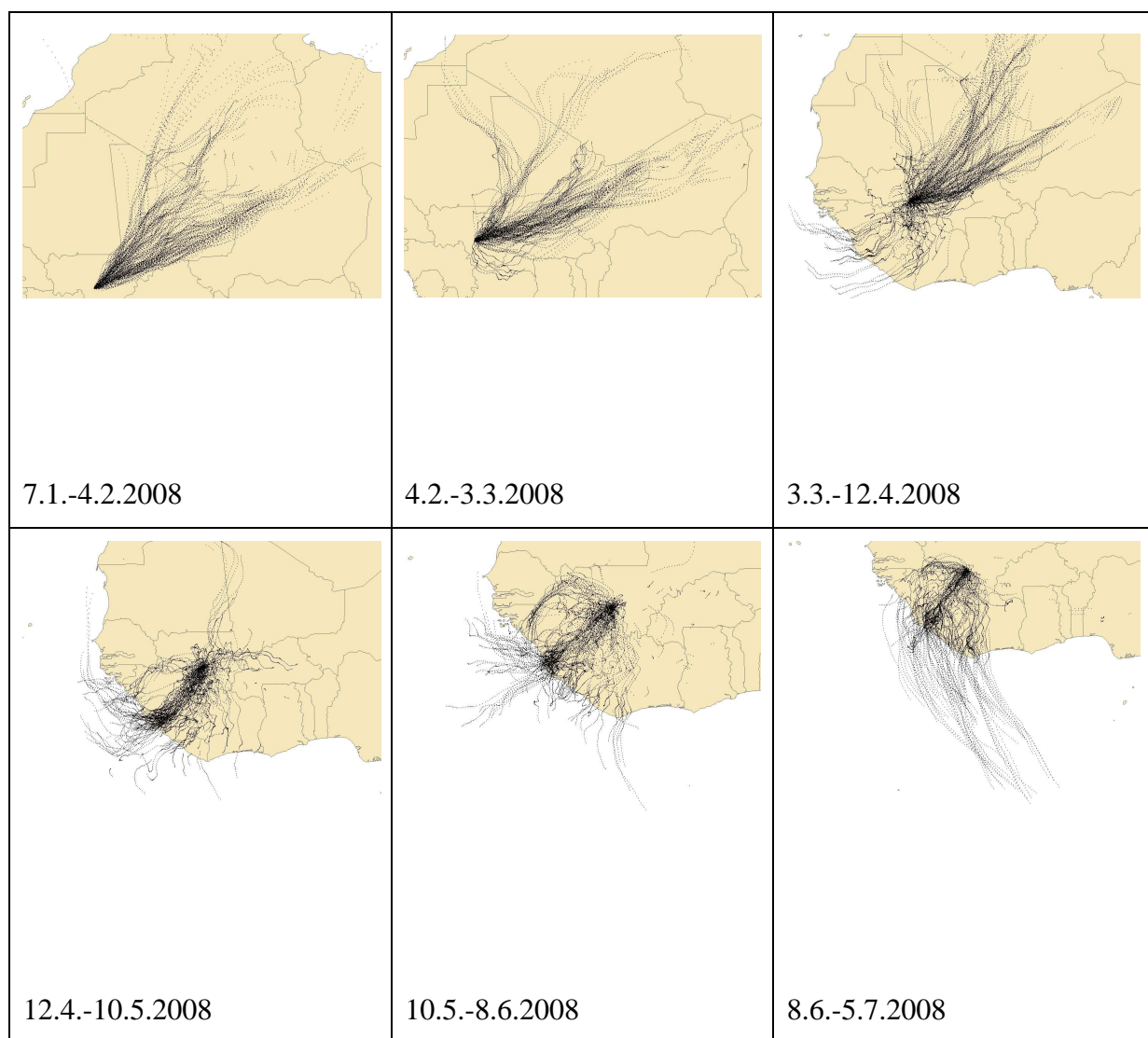


Figure E 42: Variability of the back trajectories for Bamako (Mali) in a six months sampling period (January – June, 2008)

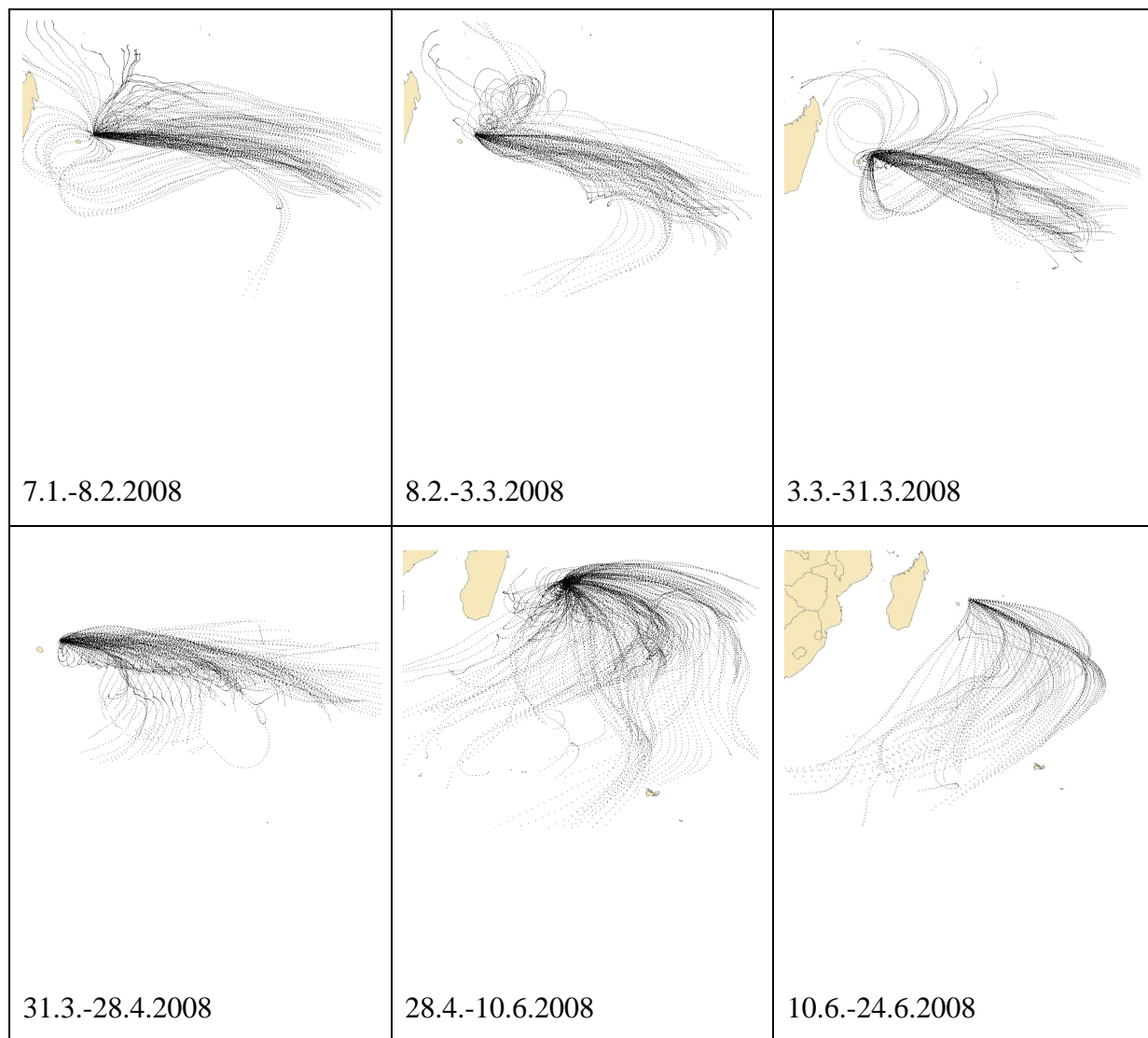


Figure E 43: Variability of the back trajectories for Reduit (Mauritius) in a six months sampling period (January – June, 2008)

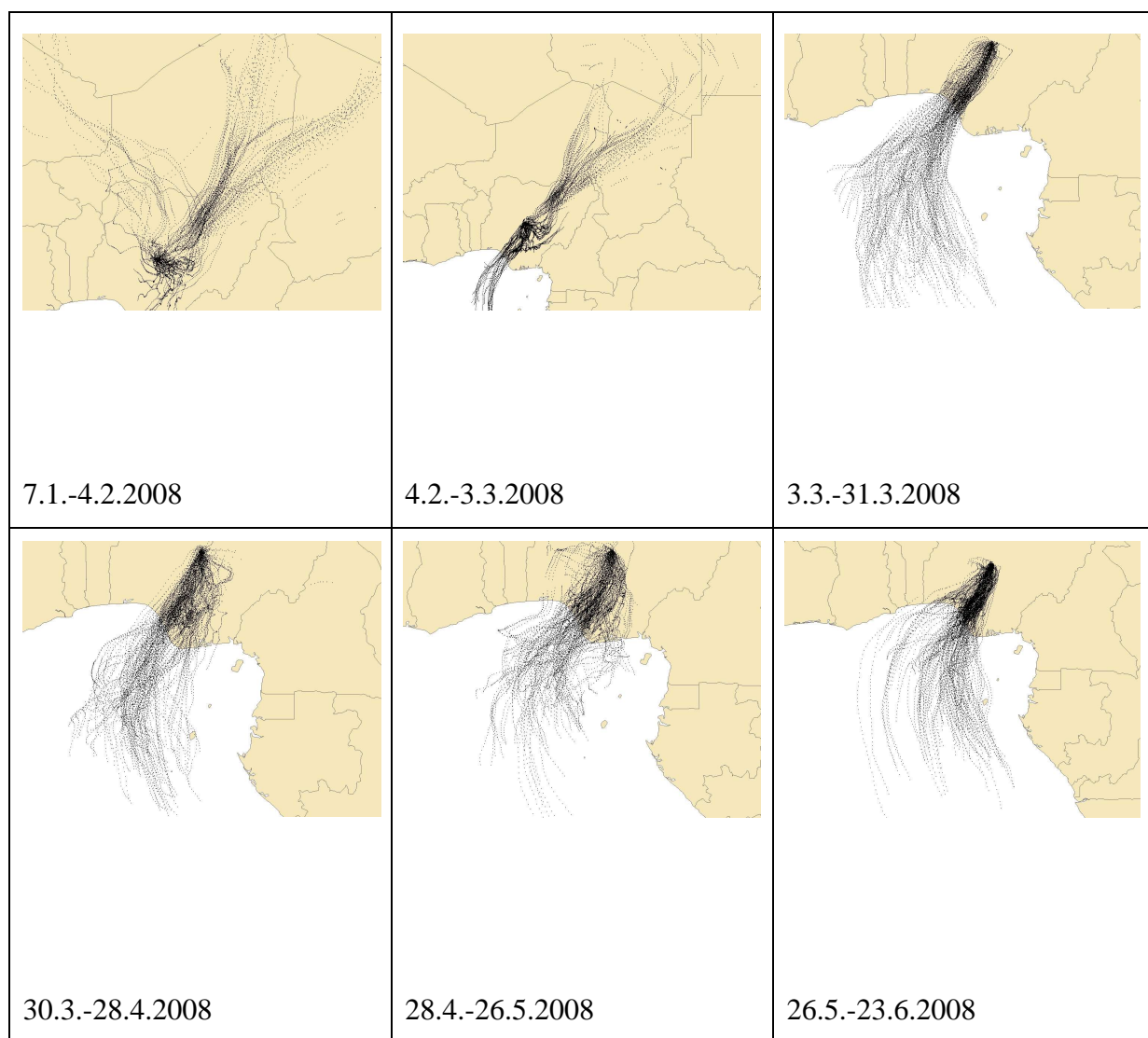


Figure E 46: Variability of the back trajectories for Sheda (Nigeria) in a six months sampling period (January – June, 2008)

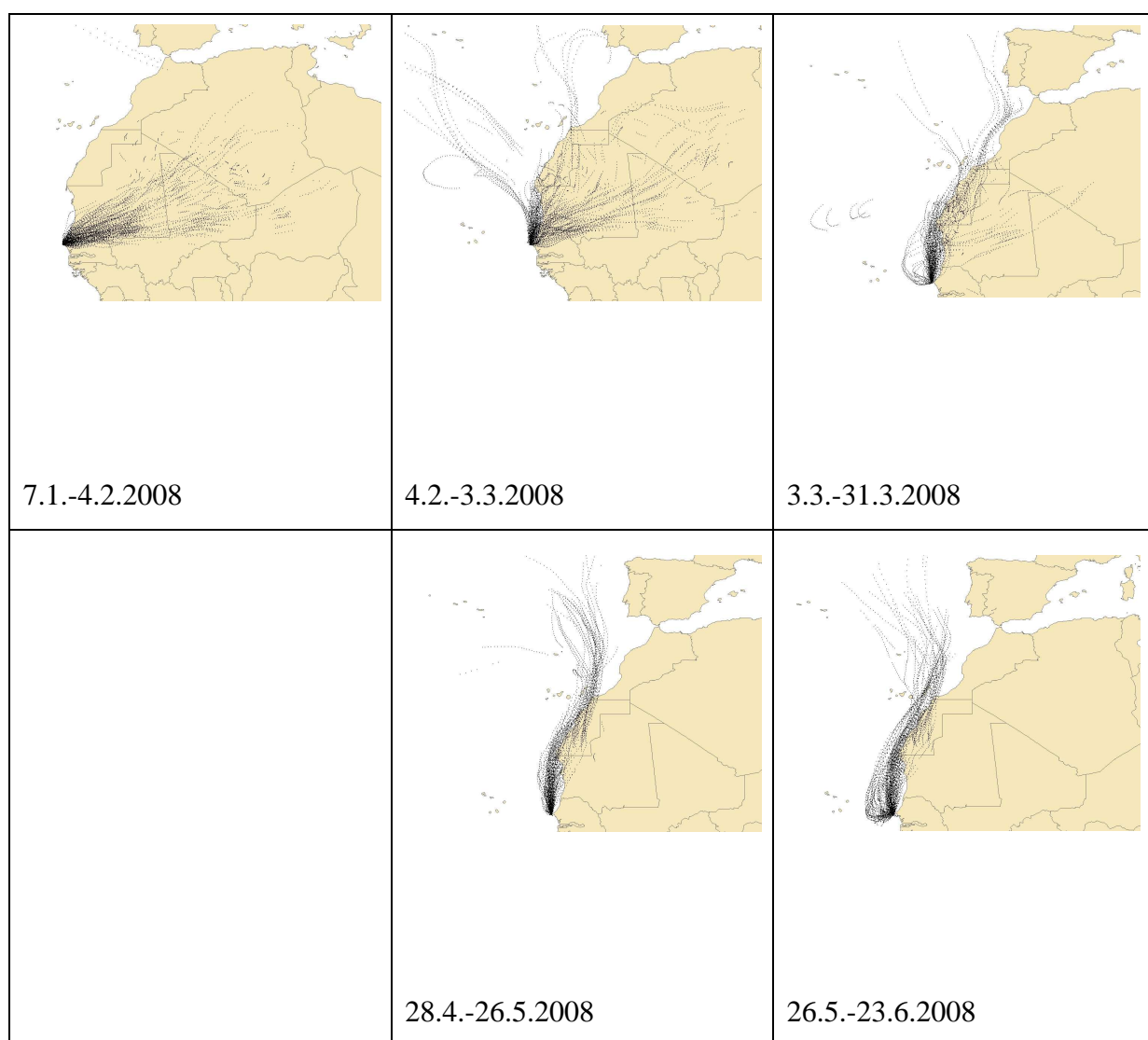


Figure E 45: Variability of the back trajectories for Darkar (Senegal) in a six months sampling period (January – June, 2008)

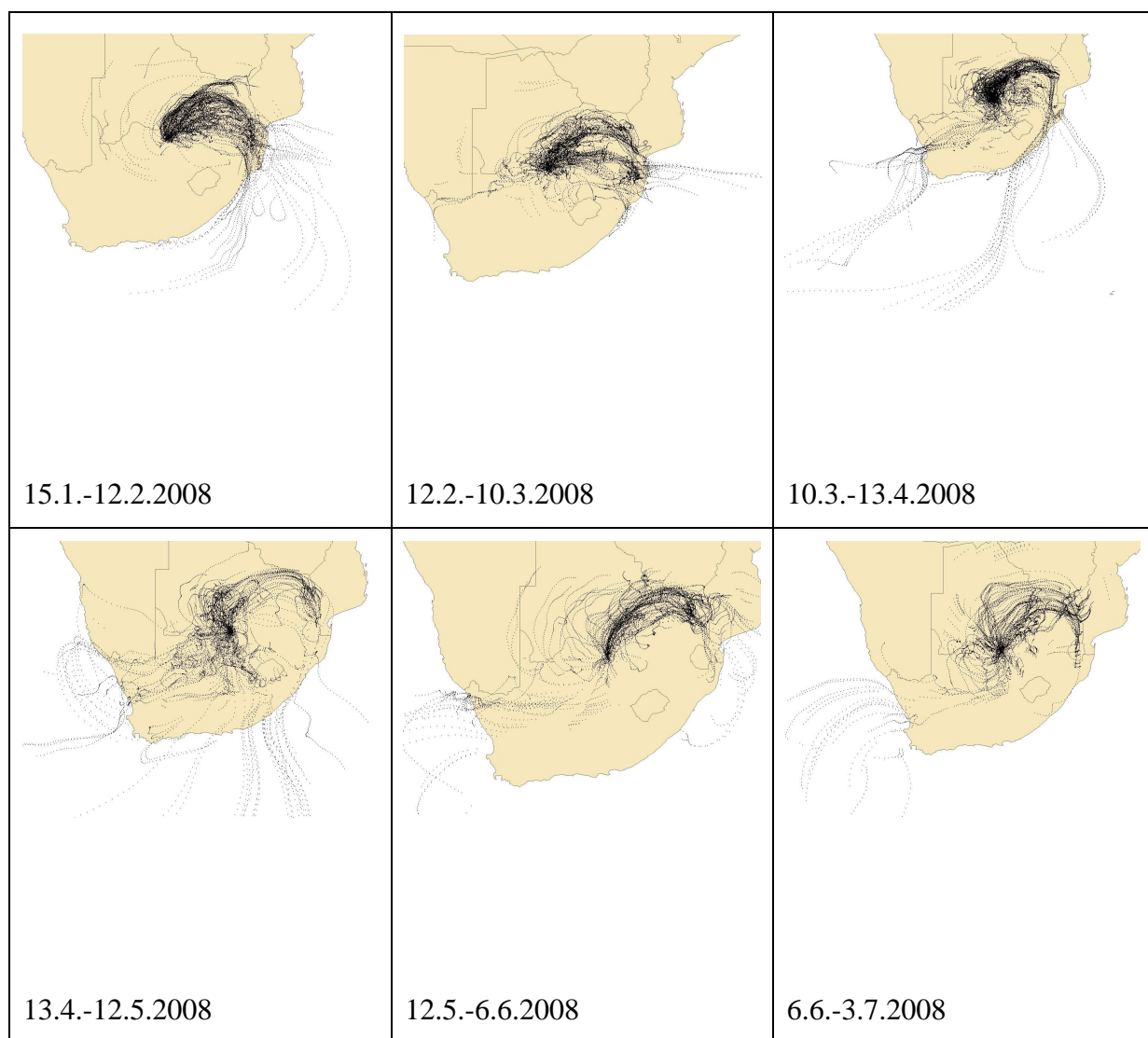


Figure E 46: Variability of the back trajectories for Barberspan (South Africa) in a six months sampling period (January – June, 2008)

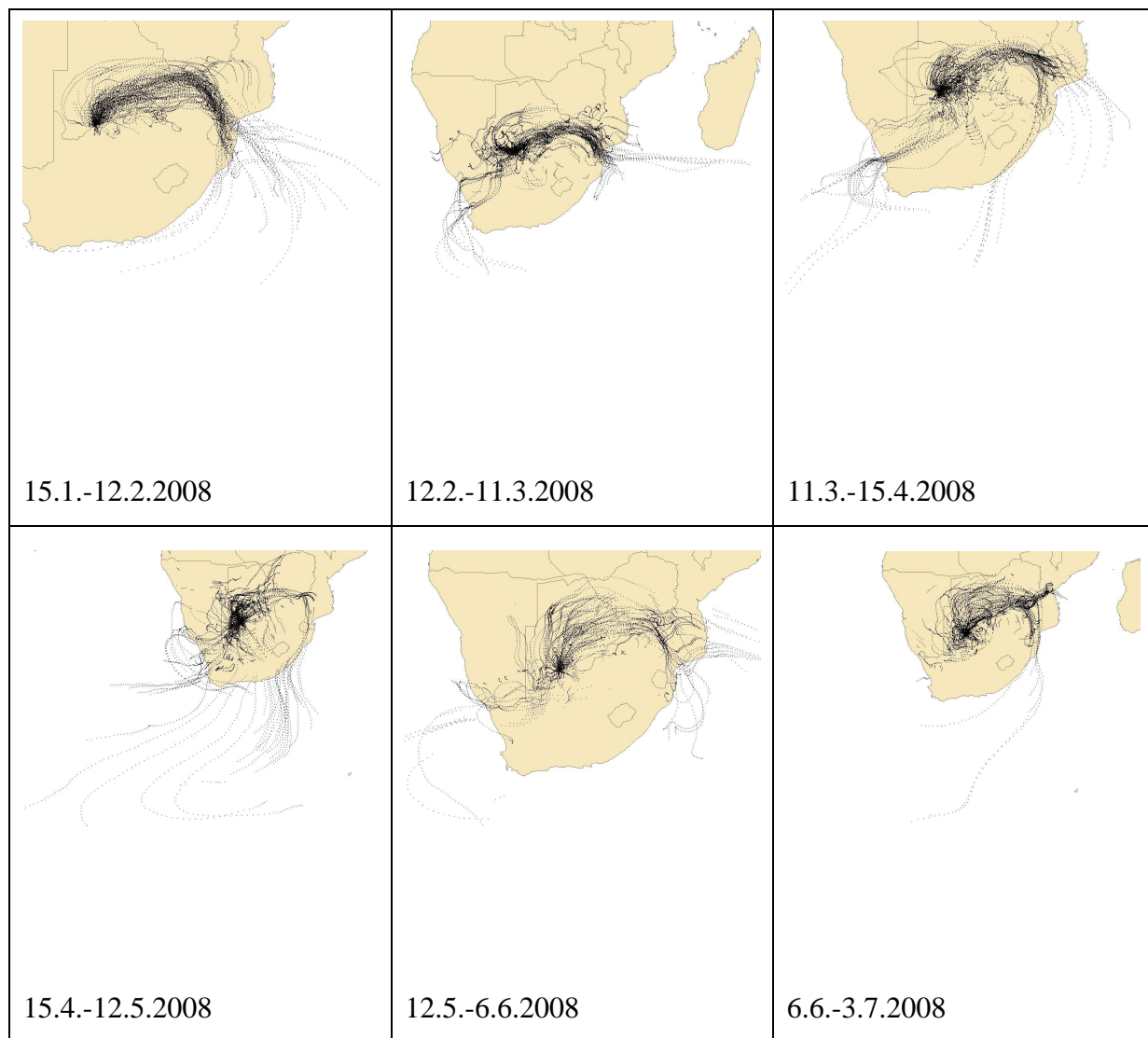


Figure E 47: Variability of the back trajectories for Molopo (South Africa) in a six months sampling period (January – June, 2008)

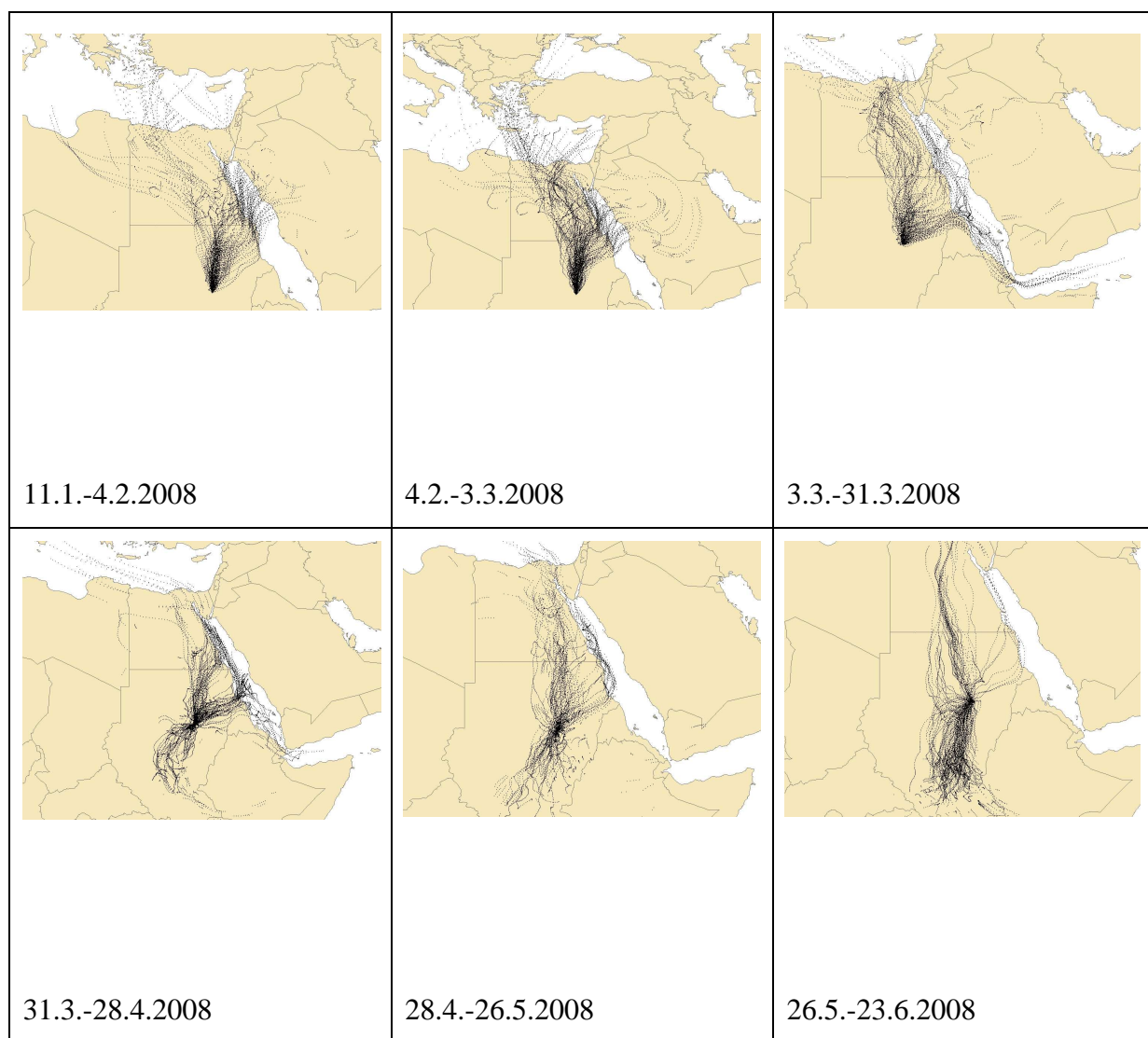


Figure E 48: Variability of the back trajectories for Khartum (Sudan) in a six months sampling period (January – June, 2008)

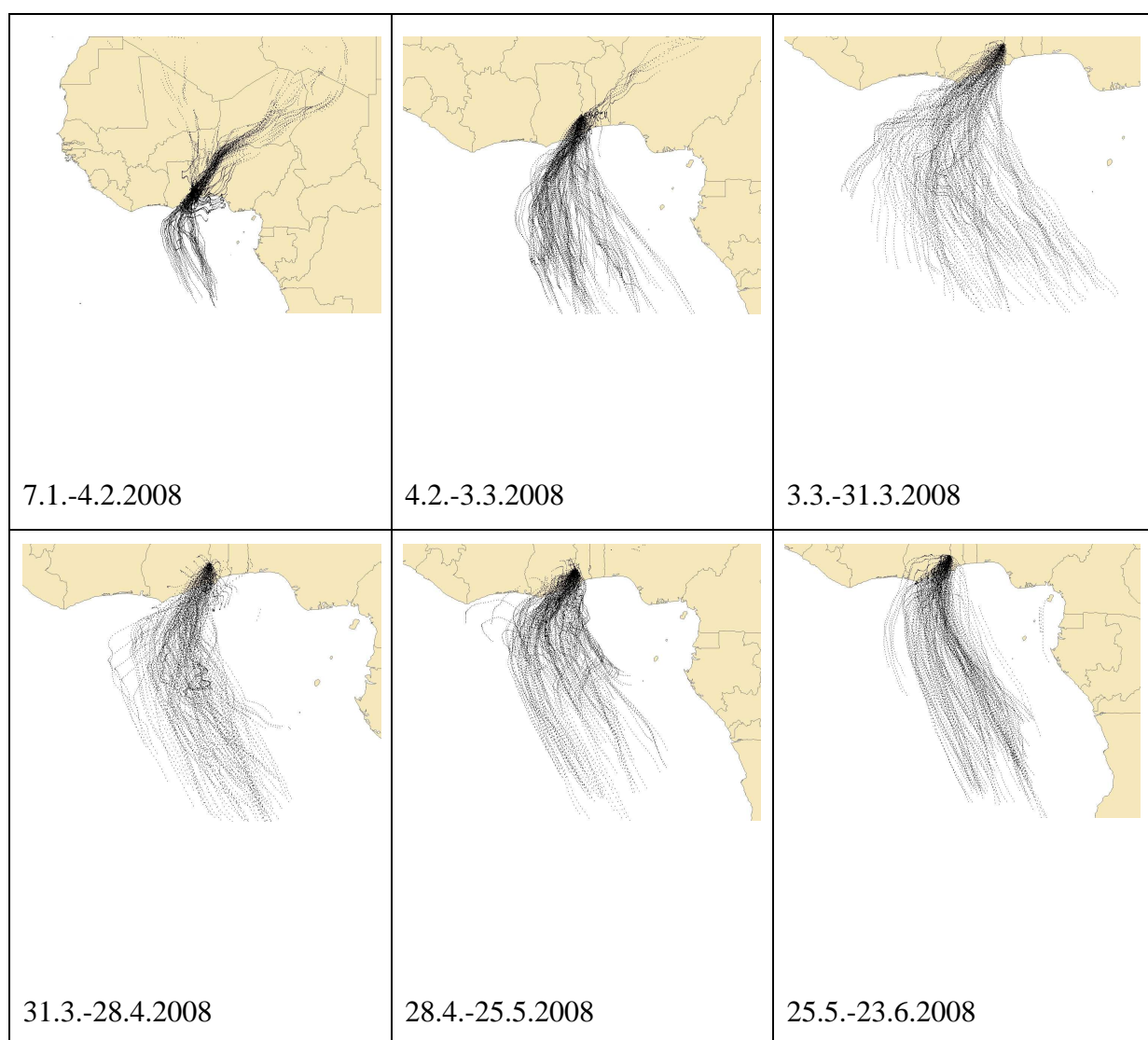


Figure E 49: Variability of the back trajectories for Koumakonda (Togo) in a six months sampling period (January – June, 2008)

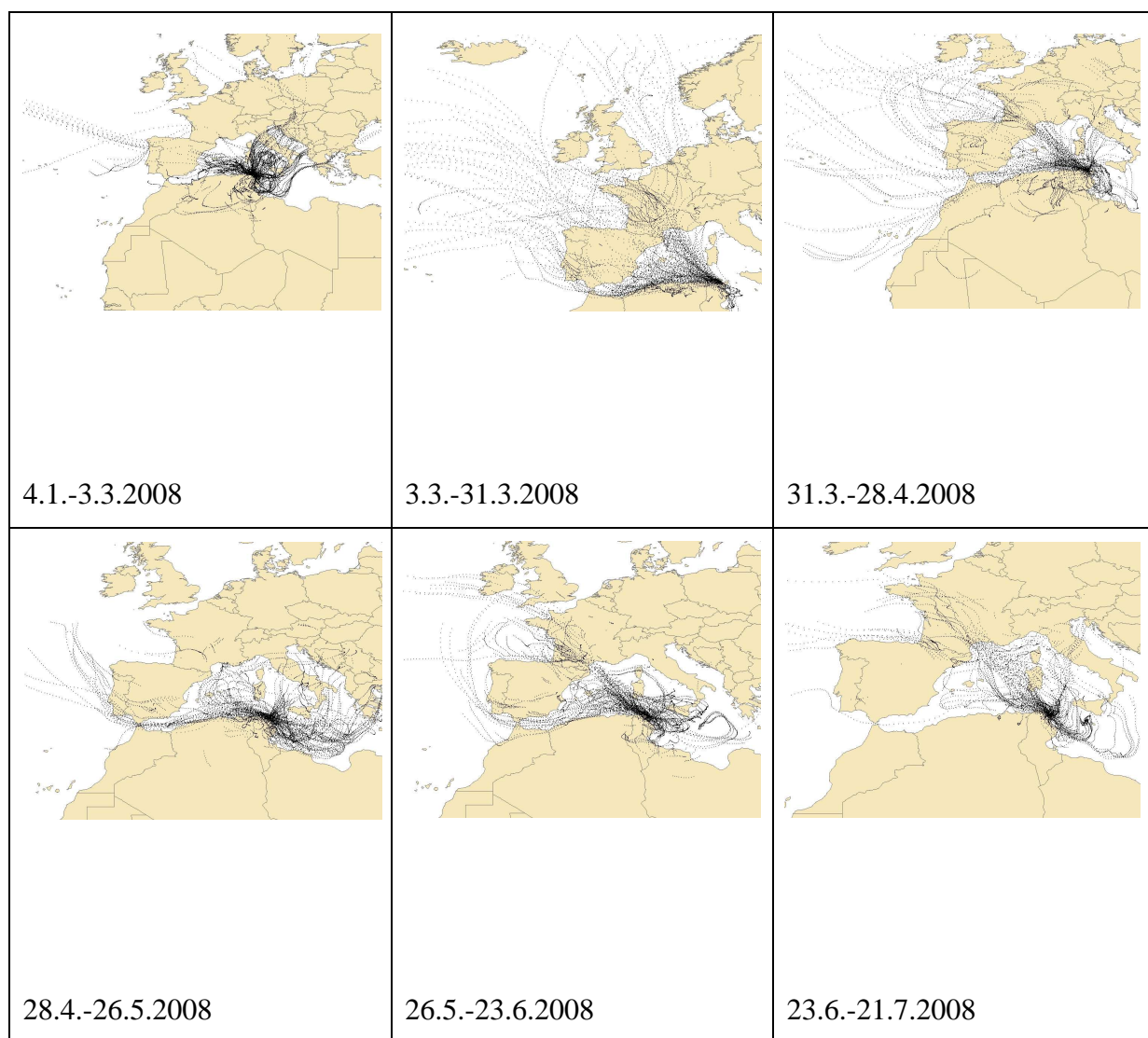


Figure E 50: Variability of the back trajectories for Tunis (Tunisia) in a six months sampling period (January – June, 2008)

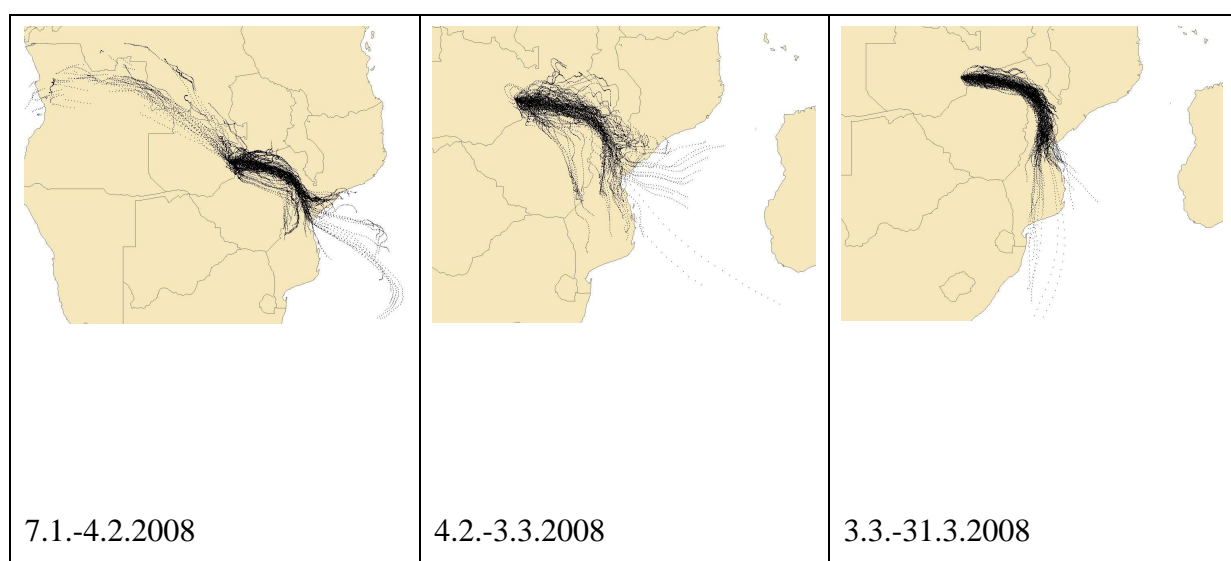


Figure E 51: Variability of the back trajectories for Lusaka (Zambia) in a six months sampling period (January – June, 2008)