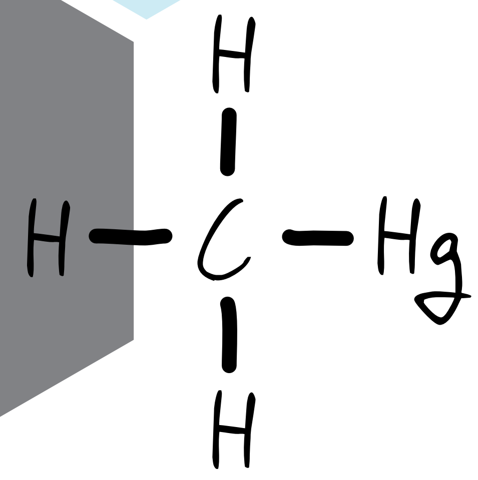

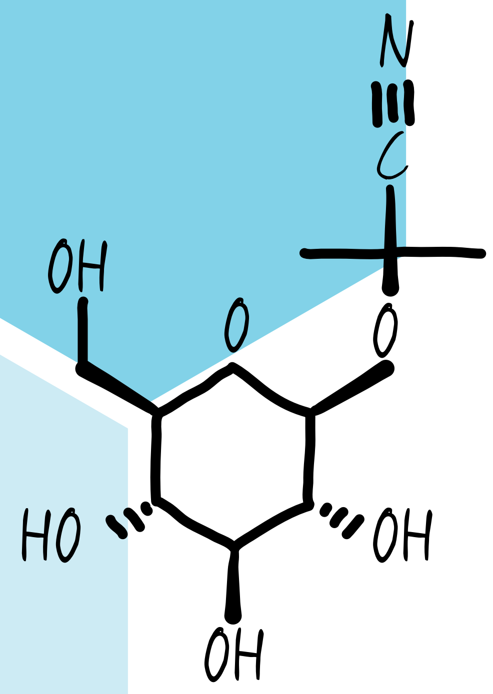

CHEMICALS OF PUBLIC HEALTH CONCERN

and their management in the African Region

REGIONAL ASSESSMENT REPORT 4 JULY 2014

World Health Organization
REGIONAL OFFICE FOR Africa

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ACRONYMS AND ABBREVIATIONS

µg/m³	Microgram per cubic meter
ASGM	artisanal small-scale gold mining
ASP	African Stockpiles Programme
COPD	chronic obstructive pulmonary disease
DDE	dichlorodiphenyldichloroethylene
DDTEQUAP	Dichlorodiphenyltrichloroethane External Quality Assessment Programme
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
IARC	International Agency for Research on Cancer
IDSR	Integrated Disease Surveillance and Response
IHR	International Health Regulations
IOMC	Inter-Organization Programme for the Sound Management of Chemicals
IPEN	International POPs Elimination Network
MEAs	multilateral environmental agreements
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCDF	polychlorinated dibenzofurans
POPs	persistent organic pollutants
PPE	Personal Protective Equipment
ppm	parts per million
PVC	polyvinyl chloride
SAICM	Strategic Approach to International Chemicals Management
S-PMA	S-phenyl mercapturic acid
TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
UNEP	United Nations Environment Programme
UNITAR	United Nations Institute for Training and Research
EPA	Environmental Protection Agency of the United States
WHO	World Health Organization

FOREWORD

Chemicals have both beneficial and negative effects on human health. They are a part of everyday life, being essential to the growth and sustainability of our communities. Today, chemicals are increasingly used to foster the prosperity of a range of economic sectors including health, agriculture, mining, education, research and many industrial processes. However, while chemicals provide benefits, they can also have harmful effects if not properly managed. Communities and individuals, whether users or non-users of chemicals, may be exposed to contamination as a result of ignorance of the risks associated, failure to employ protective measures and ineffective implementation and enforcement of safety regulations for storage, transportation and disposal of these chemicals.

Chemicals of public health concern such as heavy metals – including lead and mercury – persistent organic pollutants and highly hazardous pesticides that are either controlled or have been withdrawn from use in developed countries continue to be employed in Africa with major environmental and human health impacts. Illegal dumping remains a prevalent issue in chemicals management in Africa. A great deal of work remains to be done, therefore, to ensure environmentally sound management of toxic chemicals while at the same time embracing the principles of sustainable development and improvement of the quality of life for humankind.

Effective education on the use of chemicals and potential health risks, rigorous enforcement of safety regulations and national and international legislation including multilateral environmental agreements, training of customs and law-enforcement officials, and stepping up of border surveillance to curb both importation of obsolete chemicals and clandestine movement of hazardous chemicals and waste must be treated by Member States in the African Region of the World Health Organization (WHO) and partners as urgent priorities immediately and addressed consistently.

Today, public concerns about the adverse impacts of chemicals on human health and the environment have made the sound management of chemicals and their associated waste an essential component of overall public health policy in countries at all stages of development. The Luanda Commitment adopted in 2010 by health and environment ministers identified chemicals management as one of the top ten continental health and environment priorities for WHO Member States in Africa. WHO and the United Nations Environment Programme (UNEP), under the auspices of the 2008 Libreville Declaration, developed a framework to reduce the risks posed by chemicals to human health and the environment in Africa. This framework was subsequently endorsed by the African Ministerial Conference on the Environment (AMCEN/14/REF/4). The International Health Regulations (2005) also provide guidance for strengthening the role of public health in managing chemical incidents and emergencies, particularly in developing and transitioning countries.

This report presents the outcome of a regionwide, comprehensive assessment of chemicals and their management in the WHO African Region. It describes the main chemicals of public health importance, their health impacts and chemicals management processes at the country level.

I firmly believe that this report merits wide dissemination to serve as both a benchmark and a springboard for Member States to plan, implement and monitor actions designed to minimize the impact of chemicals on human health.

Dr Luis Gomes Sambo
WHO Regional Director for Africa

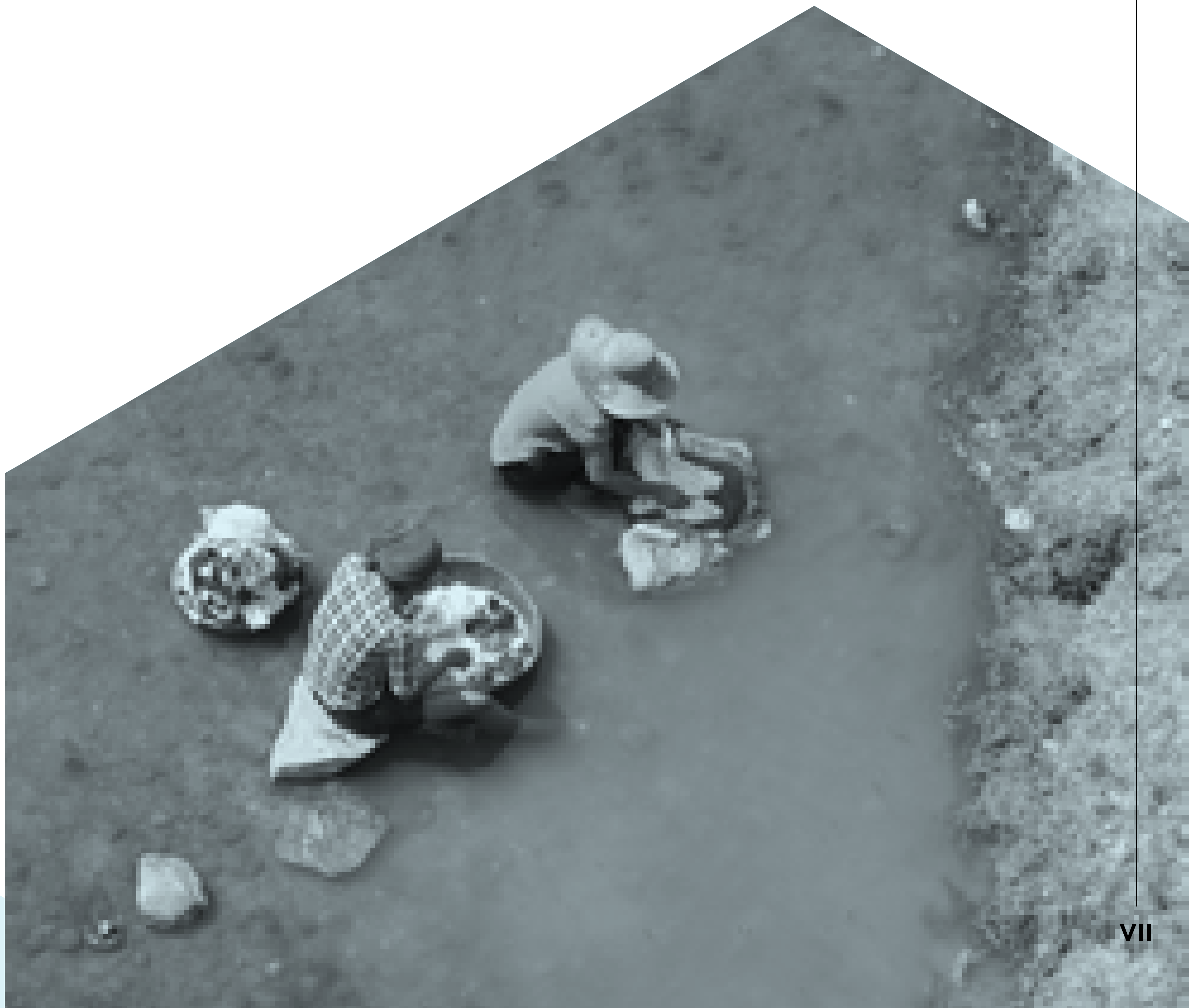
ACKNOWLEDGEMENTS

The preparation of this report was coordinated by Dr Magaran Monzon Bagayoko, Regional Adviser and acting Programme Area Coordinator, Protection of the Human Environment, under the overall direction of Dr Tigest Ketsela, Director, Health Promotion Cluster, WHO Regional Office for Africa.

Mr Michael Mesfin Habtu, WHO consultant and expert in environmental chemistry, based in Brazzaville, Congo, was responsible for technical coordination of the assessment and initial drafting of the report. The technical reviewer, editor and proofreader was Dr Tim Meredith, expert in clinical toxicology and chemical safety and a former WHO senior adviser on health and environment, Chagford, United Kingdom. The contribution of Carolyn Vickers, Joanna Tempowski and Maria Neira from WHO headquarters in the preparation of the report is gratefully acknowledged.

The text was reviewed, finalized and adopted by the Technical and Scientific Committee for the Development of a Health and Environment Integrated Observatory on Chemicals and by the 17th Session of the WHO/UNEP Joint Task Team on Implementation of the Libreville Declaration on Health and Environment in Africa, held 6-18 June 2014.

The WHO Regional Office for Africa is also grateful to WHO country offices and particularly to the protection of the human environment focal persons for their valuable contributions to the assessments undertaken at the country level.



1 INTRODUCTION

THIS REPORT AIMS TO ASSESS THE CURRENT STATUS OF CHEMICAL RISKS TO HUMAN HEALTH IN THE AFRICAN REGION

1.1 BACKGROUND

Chemical substances and their derivatives are vital in many economic activities including health, agriculture, mining, infrastructure, research, and industrial processes. However, the large-scale production and use of chemicals has been accompanied by the release into the environment of many types of substances that have consequently contaminated environmental media, resulting in the exposure of humans to levels of chemicals that cause adverse impacts on health and the environment.

Public concern about the adverse impacts of chemicals on human health and the environment has made the sound management of chemicals and their associated waste an essential component of overall public health policy in countries at all stages of development. With the increasing exploitation of natural resources and expansion of agriculture in Africa, a range of toxic effluent is discharged or emitted into the environment, often at levels well in excess of those that would be allowed in developed countries. Heavy metals such as lead and mercury, persistent organic pollutants (POPs) and highly hazardous pesticides that are either controlled or banned in developed countries continue to be used in Africa with major environmental and health impacts. A great deal remains to be done, therefore, to ensure that the management of toxic chemicals is environmentally sound and embraces the principles of sustainable development and improvement of the quality of life for humankind.

Although Africa currently is neither a major producer nor consumer of chemicals in global terms, reports generally show that the level of chemical risk faced is disproportionately higher on the continent than in countries with sufficient resources to effectively manage and monitor chemical use.[1] Addressing the public health hazards associated with chemicals is a crucial but, at the same time, challenging task for Africa given the limited understanding of these hazards and the generally low capacity of health systems to monitor and manage chemical incidents. In order to define strategies to reduce the impact of chemicals on health, the African Region of the World Health Organization (WHO) embarked on the comprehensive assessment survey reported in this document with a view to identifying the chemicals that are of major public health concern in the Region, assessing the public health hazards associated with them, understanding the distribution of the burden of risk across the Region, and evaluating systems for their management.

1.2 JUSTIFICATION

In the revised International Health Regulations (IHR) 2005, WHO provides guidance for strengthening the role of public health institutions in chemical incident and emergency prevention, preparedness, detection, alert, response, and recovery, particularly for developing and transitioning economies.[2] The IHR regulations require a fundamental change in the obligation of Member States, from notifying WHO only of outbreaks of certain communicable diseases to the requirement that WHO be notified of all public health emergencies of international concern, including those caused by chemicals.

Chemical incidents with a risk of human exposure present an important public health challenge for Africa. Such incidents range from obvious chemical releases such as leaks or spills to events that are less obvious or immediately apparent such as contamination of consumer products. The need for urgency in addressing chemical problems was highlighted in the Luanda Commitment when it identified chemicals management as one of the top African health and environment priorities that must be addressed to accelerate implementation of the Libreville Declaration. Consequently, the WHO/UNEP Joint Task Team for Implementation of the Libreville Declaration developed a framework to reduce chemical risks to human health and the environment in Africa. This framework was endorsed by the African Ministerial Conference on the Environment (AMCEN/14/REF/4).

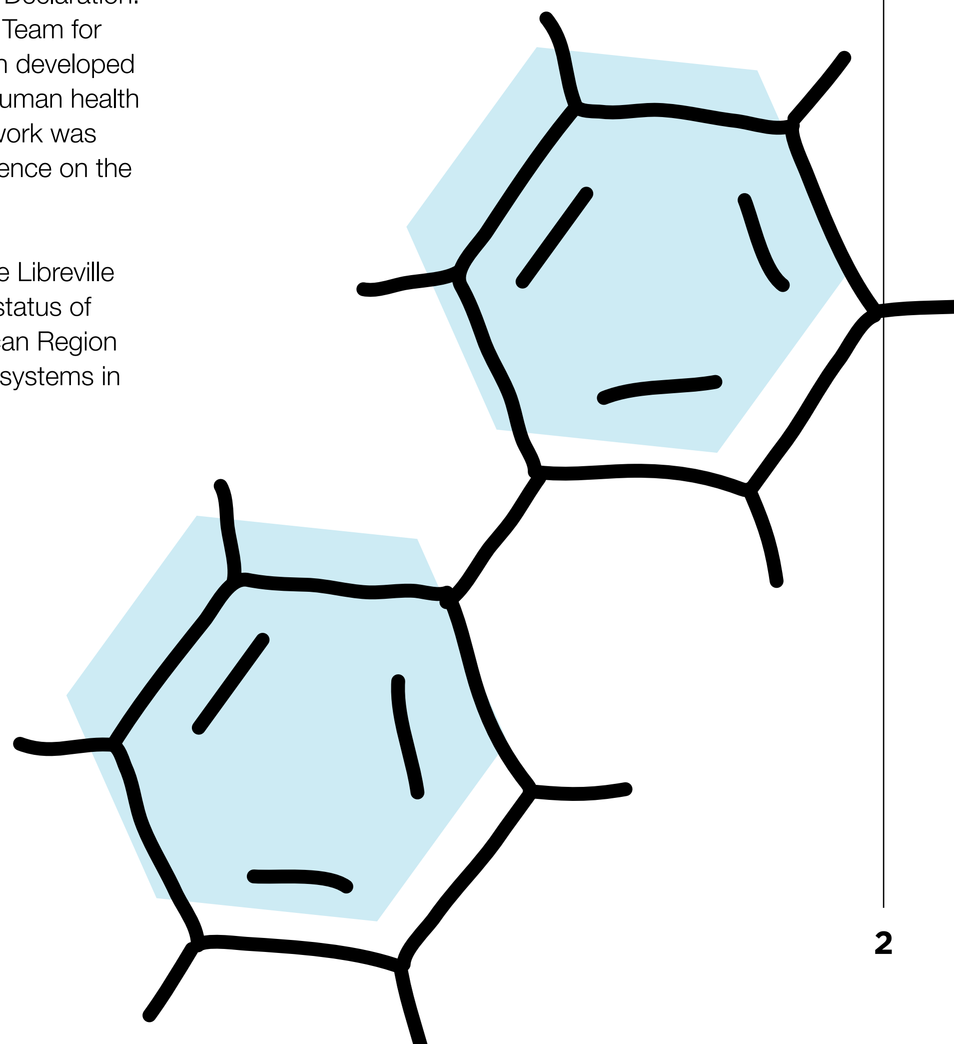
This report was prepared in the spirit of the Libreville Declaration. It aims to assess the current status of chemical risks to human health in the African Region and the status of chemicals management systems in this region.

1.3 OBJECTIVES AND EXPECTED RESULTS OF THE ASSESSMENT

The general objective of this assessment is to contribute to the implementation of the framework on the reduction of chemical risks to human health in the African Region.

The specific objectives of this assessment are to:

A Identify chemicals that have a significant impact on public health and outline potential sources of exposure to these substances;
B Assess the public health impacts and management systems of the chemicals concerned;
C Assess the capacity of health systems, including public health laboratories and poisons centres, to monitor and manage chemical events;
D Identify the opportunities and challenges related to the management of chemicals at national and regional levels;
E Develop a database of chemicals based on these findings, including information drawn from self-assessment reports by Member States; and
F Propose priority actions required to fast track the development and implementation of a regional plan to reduce chemical risks to public health in the WHO African Region.



1.4 EXPECTED DELIVERABLES

(a) A regional database on chemicals created and made available to Member States; and
(b) The report on the assessment of the impact of chemicals on public health and their management in the WHO African Region finalized and disseminated to stakeholders.

1.5 METHODOLOGY

An implementation plan outlining the major activities to be undertaken during the assessment phase with a clear time frame was prepared, discussed and validated. There were five main components to the assessment:

(a) an in-depth literature review
(b) designing of a standardized self-assessment tool that was validated by WHO before being disseminated to all Member States in the WHO African Region
(c) data collection
(d) data analysis and interpretation
(e) debriefing and feedback

1.5.1 LITERATURE REVIEW

The purpose of the literature review was to obtain background information on chemicals of public health concern at global and regional levels, review the public health impacts of the chemicals and assess existing chemicals management systems. Particular emphasis was given to studies conducted in the African Region.

The literature review covered published scientific literature as well as official and grey literature mostly produced in the last 25 years. The following sources were used:

(a) MEDLINE (via PubMed) database, Google Scholar and Google
(b) An online search complemented by a bibliographic search of published literature
(c) An online search of journals WHO subscribes to using the WHO Regional Office for Africa library database
(d) An online search of published national chemicals management profiles and national implementation plans of Member States using the UNITAR (United Nations Institute for Training and Research) website (www.unitar.org), situation assessments and needs analyses conducted as part of the follow-up to the Libreville Declaration on Health and Environment in Africa, and other relevant documents

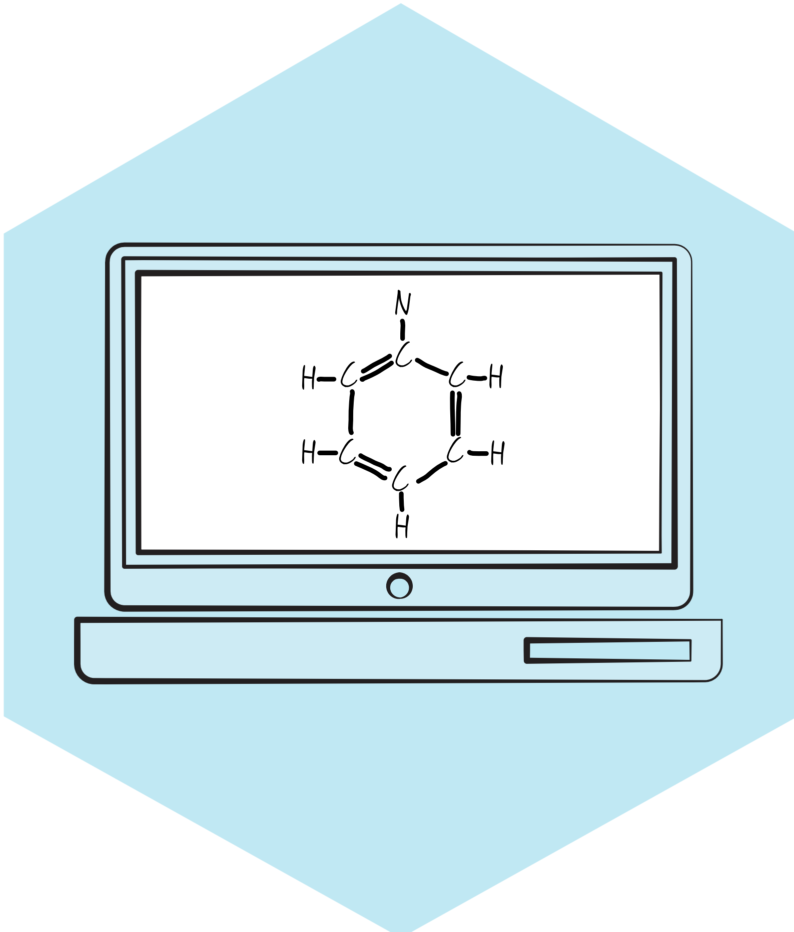
1.5.2 SELF-ASSESSMENT TOOL

A standardized self-assessment questionnaire was initially developed in English. After being reviewed and validated by the Protection of the Human Environment Programme in the WHO Regional Office for Africa, it was translated into French and Portuguese and disseminated to all Member States in the Region through WHO communication channels. WHO country offices were asked to assist with the survey by forwarding the questionnaires in a timely manner to appropriate national counterparts and stakeholders, and to undertake the follow-up actions necessary to ensure completion. WHO country offices were also requested to return the completed questionnaires to the WHO Regional Office for Africa by the deadline (see Annex 2 for the questionnaire).

1.5.3 DATA COLLECTION

Data was collected from Member States by means of the self-assessment questionnaire. Follow-up was undertaken through country offices to ensure that the questionnaires were properly completed. Inconsistent or anomalous data in the reports was resolved through telephone or e-mail discussions with WHO focal points.

Forty Member States provided data: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Chad, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Madagascar,



Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Sudan, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia and Zimbabwe.

The data collected from Member States was supplemented with online searches of reputable sources including the WHO Event Management System, UNITAR and the World Bank. The chemical profiles of some African countries are available through the UNITAR website and were searched as necessary, but at the time most profiles were not up to date.

1.5.4 DATA ANALYSIS AND INTERPRETATION

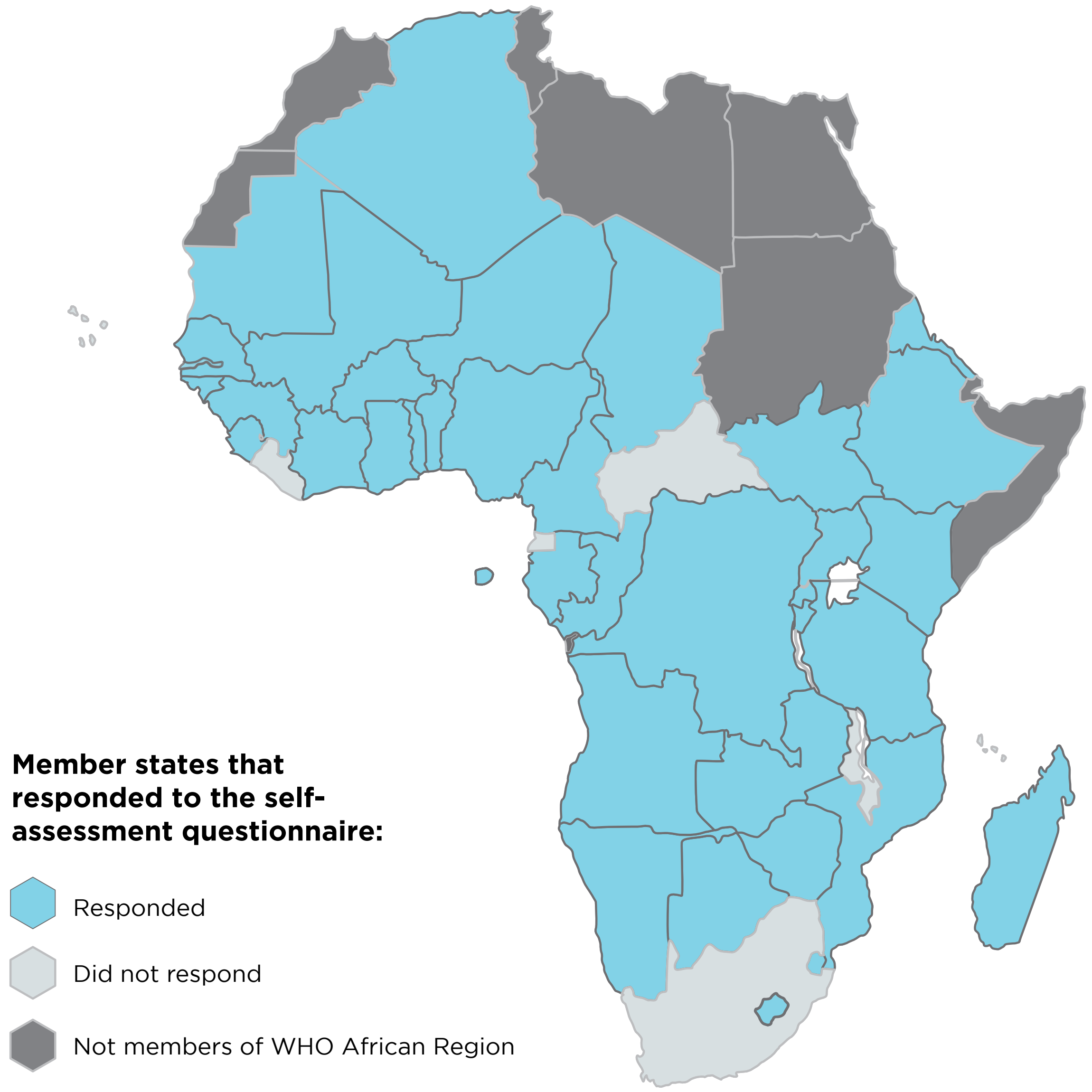
Data extracted from the self-assessment questionnaires was entered into a pre-designed SQL2008 database, analysed using ArcGIS and interpreted.

Data on chemical risks and their management systems in the African Region is scanty, if not absent, for most countries, and when available, it is either out of date or incomprehensive. These limitations notwithstanding, the findings of this assessment should provide a basis for preparation of a substantive and viable action plan for the management of chemical risks in the African Region.

1.5.5 DEBRIEFING AND FEEDBACK

In order to propose priority actions to reduce chemical risks to public health in the African Region, chemicals of public health concern were identified; a detailed description of the potential risks developed; the regional capacity for prevention, detection and management of the chemicals established; and a gap analysis of the findings undertaken. The findings of the assessment were scrutinized and enriched with information from debriefing and feedback activities.

Figure 1: Member states that responded to the self-assessment questionnaire



2 CHEMICALS OF MAJOR PUBLIC HEALTH CONCERN IN THE AFRICAN REGION

Although chemical substances are widely used in almost all economic sectors, their utilization is much higher in some specific areas. Data collected from Member States show that chemical use is more pronounced in agriculture and industry, mainly manufacturing, mining and petroleum oil refining. The chemicals mostly utilized by the agricultural sector are pesticides and fertilizers. Insecticides such as DDT are also reported to be common in the health sector for the control of many vector-borne diseases such as malaria and typhus. Other sectors that were reported to be significant users of chemicals included construction, transport, power generation and tourism.

The public health impact of a chemical is determined by an assessment process that aims to provide a consensus scientific description of the risks resulting from exposure to the chemical. In order to identify chemicals that are of major public health concern, certain epidemiological factors need to be taken into account. These factors include the substance's prevalence, toxicity, adverse public health impacts and tendency to spread. Using the self-assessment questionnaire, Member States identified the sectors that were the main users of chemicals and listed the chemicals that were most used. Of the 40 countries responding to the survey, 32 (80%) provided an extensive list of chemicals and also identified those of potential public health concern. Among the many chemicals listed by Member States, the following were identified as being of major public health concern in the WHO African Region:

- Heavy metals particularly mercury, lead, cadmium and arsenic
- Fluoride
- Cyanide
- Air pollutants carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, etc.
- Benzene, including polycyclic aromatic hydrocarbons (PAHs)
- Asbestos
- POPs, including dioxins, furans and polychlorinated-biphenyls (PCBs)
- Hazardous pesticides, mainly organophosphates and organochlorines

Exposure to the chemicals or groups of chemicals listed above may result in acute or chronic health effects. Acute effects typically result from short-lived exposure to high concentrations of a chemical, but may subsequently be followed by long-term effects. Chronic, low-level exposure is more likely to result in the gradual development of an illness. Figure 1 lists the chemicals reported by Member States.

CHEMICAL USE IS MORE PRONOUNCED IN AGRICULTURE AND INDUSTRY, MAINLY MANUFACTURING, MINING AND PETROLEUM OIL REFINING

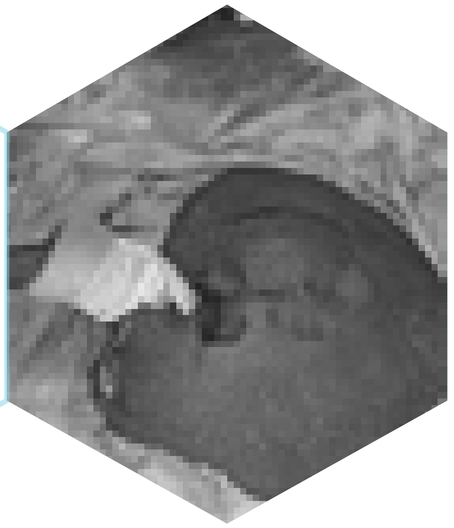
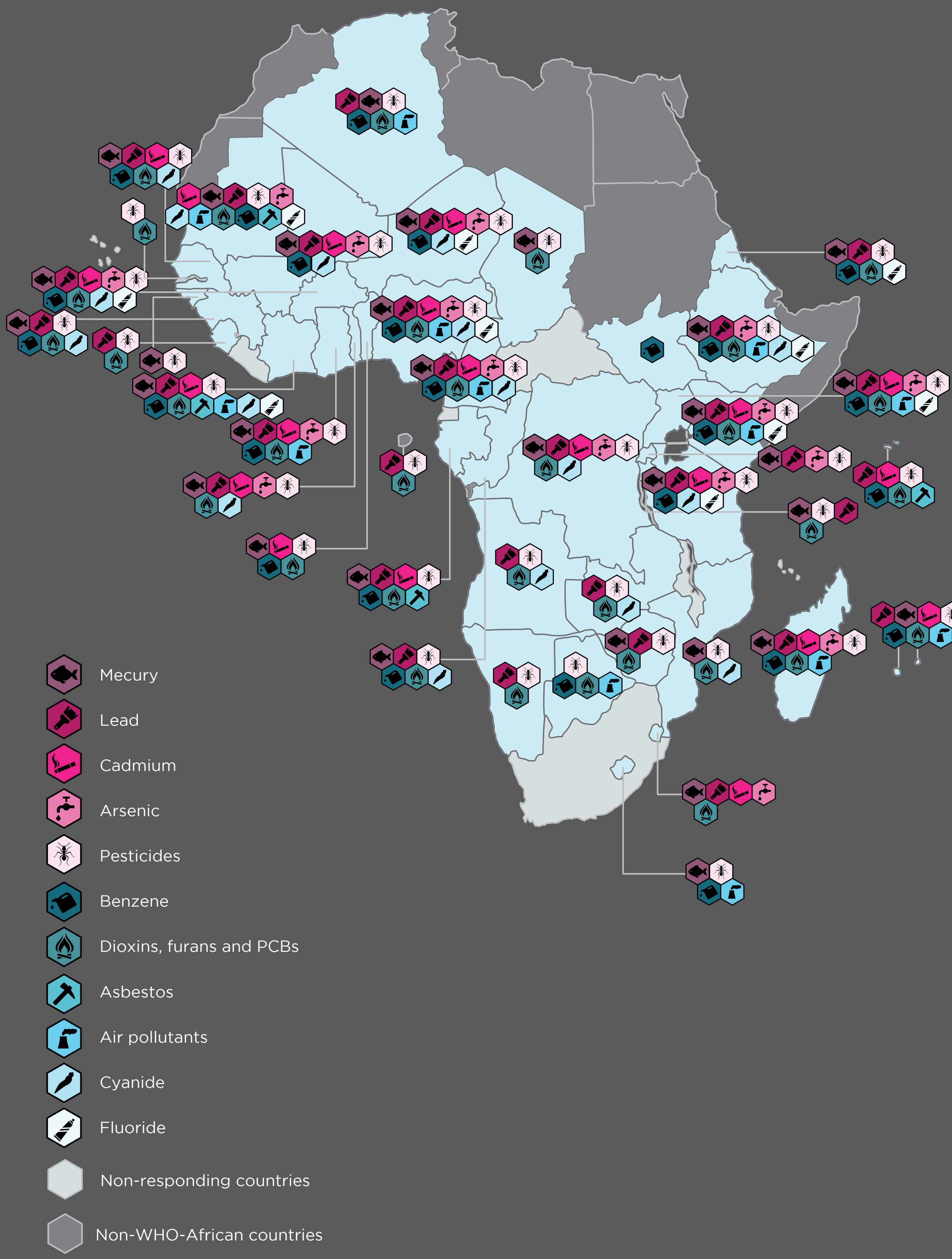


Figure 2: Chemicals of major public health concern in the WHO African Region

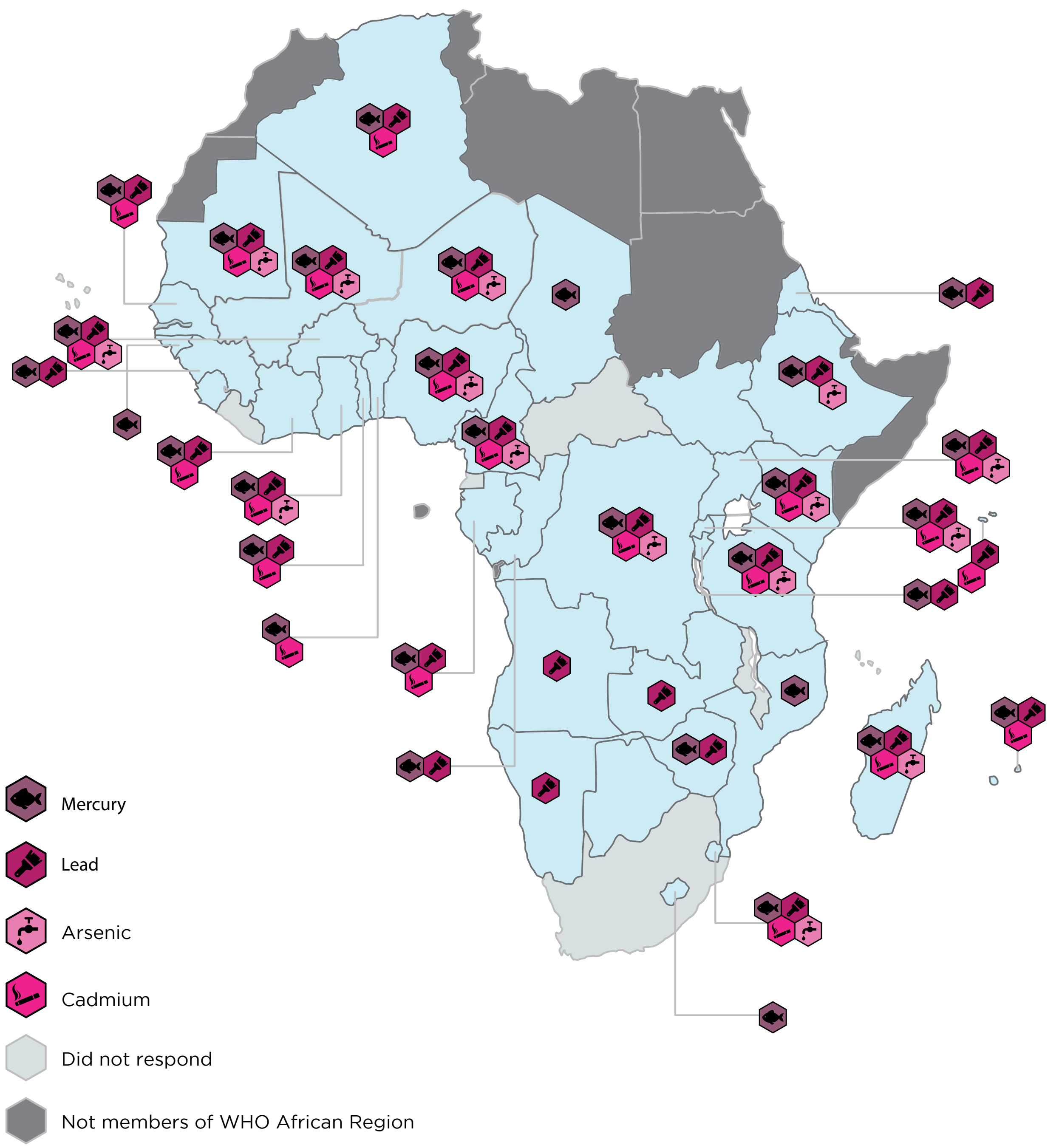


2.1 HEAVY METALS

The term "heavy metal" is loosely defined, as no consensus on its definition exists in the literature. Many definitions have been proposed, some based on substance density, others on atomic number or atomic weight and some others on chemical properties or features of toxicity. From a public health point of view, the term heavy metal usually refers to a metal or semi-metal that has the potential to cause human or environmental toxicity. These may include lead, mercury, cadmium, cobalt, nickel, iron, thallium, bismuth and arsenic.

Based on Member States reports and the literature review, the main threat to human health from heavy metals in the African Region is from exposure to mercury, lead, cadmium and arsenic. These metals have been studied extensively and their effects on human health are reviewed regularly by WHO. Heavy metals are generally considered to be especially toxic to humans and animals, and exposure to them even at low concentrations is associated with diverse health effects including but not limited to neurotoxicity and carcinogenicity.[3,4,5,6,7] The countries in the African Region where mercury, lead, arsenic and cadmium are of health concern are shown in Figure 3.

Figure 3: Distribution of heavy metals in the WHO African Region



2.1.1 MERCURY

Public health impact

Mercury is a heavy metal that exists in the environment in three chemical forms: elemental or metallic mercury, inorganic mercury compounds and organic mercury compounds. In high enough doses, all these forms can produce toxic effects. Humans are exposed to mercury by various means. The most common route for exposure to elemental mercury is through the lungs, as the metal volatizes at room temperature. The vapour irritates the lungs, affects the kidneys, easily penetrates the blood-brain barrier and is neurotoxic.[8,9] Children are vulnerable to the toxic effects of mercury, particularly during the early stages of brain development.[10]

Exposure to methylmercury, an organic form of mercury, occurs mainly by ingestion of contaminated fish. Methylmercury is the most toxic form of mercury. It has been classified by the International Agency for Research on Cancer (IARC) as a possible human carcinogen[11] and, moreover, it is likely that its carcinogenic and neurotoxic effects have no low-dose threshold. The best known cases of severe methylmercury poisoning are of the industrial release of methylmercury in Minamata Bay, Japan, in 1956 and of the treatment of wheat with a methylmercury fungicide in Iraq in 1971. In each of these cases hundreds of people died and thousands were affected in other ways and many left with permanent health consequences.

In Africa, human exposure to elemental mercury is mainly associated with artisanal small-scale gold mining (ASGM). Epidemiological literature on the health impacts of mercury exposure among ASGM communities highlights a prevalence of neurological disorders, kidney dysfunction, and immune and autoimmune toxicity and dysfunction. According to research in Ghana among ASGM communities more than 50% of miners and 25% of non-miners surveyed exhibited serious mercury toxicity, and up to 7% of the study population had neurological problems.[12] In a study in Burkina Faso, an elevated prevalence of symptoms such as frequent headaches, sleep disorders, unusual tiredness, trembling and vision disorders was reported in communities involved in ASGM or gold dealing and selling.[13] In northern Mozambique, where ASGM is practised widely, mercury concentrations of up to 30 $\mu g/m^3$ have been reported. These levels are 30 times higher than acceptable according to WHO guidelines for exposure to mercury vapour, so it is not surprising that individuals involved in amalgamation activities present with a range of complications, including neurological disorders.

Potential sources of exposure

The main risks of environmental mercury release result from human activity. Mercury is used in mining to extract gold from ore by forming amalgam, a mixture of mercury and gold. This method is used in the ASGM industry because it is cheaper than most other methods, can be used by one person independently and is comparatively quick and easy.

ASGM is the main source of direct human exposure to high levels of elemental mercury. ASGM is widely practised in most sub-Saharan African countries, which makes mercury exposure a regional issue (Figure 3). Miners vaporize up to 1.5 gram of elemental mercury into the environment to separate 1 gram of gold from gold-mercury amalgam.[14] As a result, miners and populations living in mining areas are at a particularly high risk of exposure to metallic mercury, especially since they do not have protective equipment. ASGM is routinely carried out near water sources, contaminating drinking water and thereby posing a high risk to communities that are dependant upon those water sources, including women and children.[15]

As a public health issue exposure to mercury in artisanal mining has gender and youth dimensions because of the demographics of the industry: women and children are engaged in gold mining and their activities span every possible procedure, including those with the highest risks of mercury exposure.[16] For example, in the Kedougou Region of Senegal, women and children are involved in processes ranging from ore extraction to burning amalgam. In the Tenkoto Region women carry out amalgamation activities in close proximity to their children.[15] In Gaoua, Burkina Faso gold mining and

Clinical features and health impacts associated with mercury

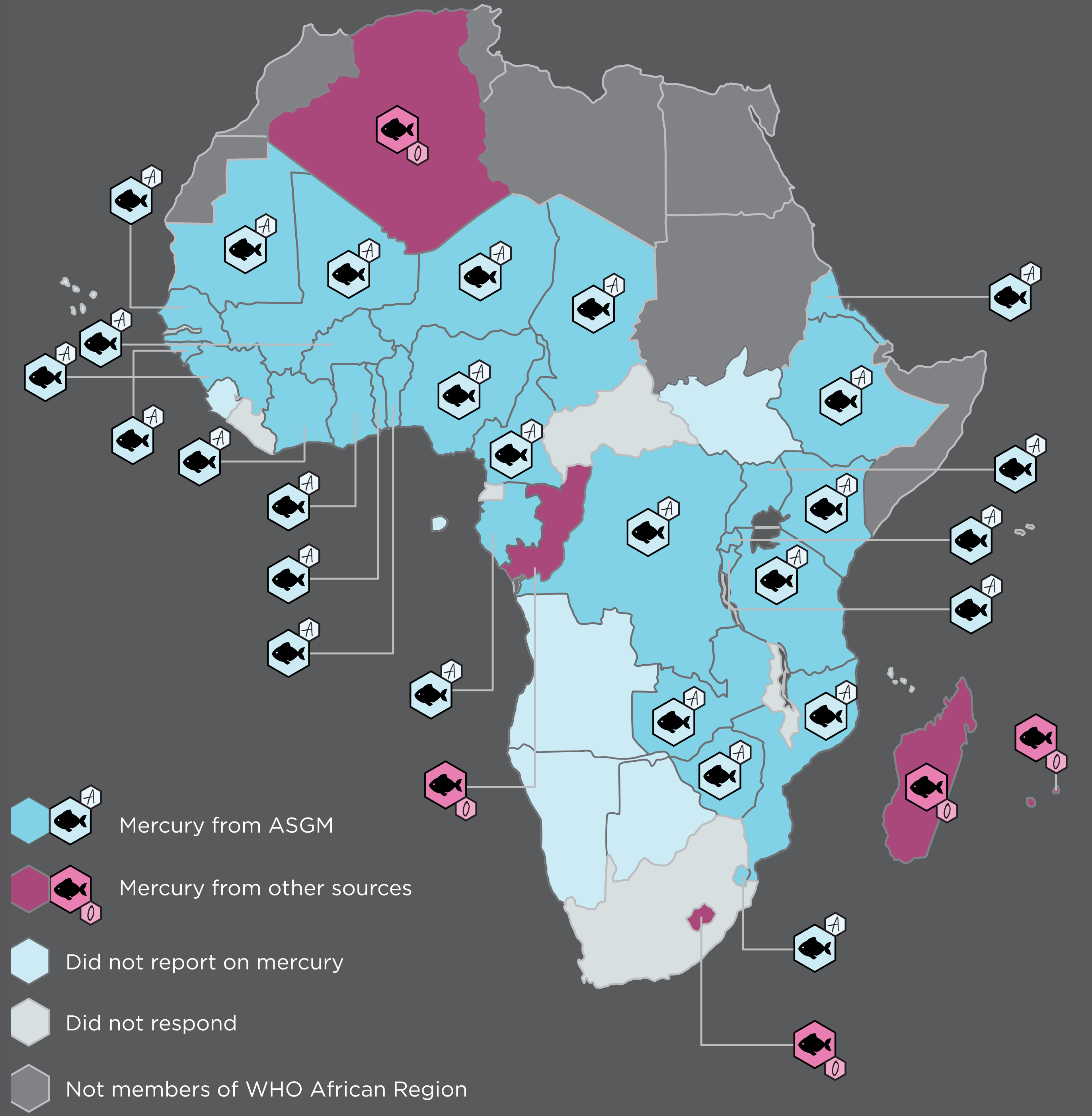
Clinical features

- Acute: Neurotoxicity leading to excessive salivation, ataxia and abnormal reflexes in children. Pharyngitis, dysphagia, abdominal pain, nausea and vomiting, bloody diarrhoea and shock. Later, swelling of the salivary glands, stomatitis, loosening of the teeth. Nephritis and hepatitis may occur.
- Chronic: Increased excitability, irritability, psychiatric disturbances, and tremors.

Health impacts

Neurological and renal damage. Complications affecting the lungs, kidneys, cardiovascular and immune systems. Tremors, impaired vision and hearing, paralysis, insomnia and emotional instability. Spontaneous abortion and other pregnancy complications in mothers. Acrodynia (pink disease).

Figure 4: Mercury as a public health concern in the WHO African Region



vending have traditionally been female-only activities.[17] Reports indicate that the proportion of the African artisanal workforce composed of women and children may range from approximately 5% in South Africa to 50% in Mali.[18]

Contaminated consumer products: The use of mercury-containing consumer products, particularly soaps and skin-lightening creams, is reported to be widespread in Africa. The mercury used in soaps and skin-lightening creams is inorganic. When combined with iodine or chlorine to become an iodide or a chloride salt the resulting chemical can be absorbed through the skin. In studies conducted in Kenya, Nigeria and Senegal, toxic levels of mercury were detected in the hair of women who habitually used soaps and skin-lightening creams containing high levels of inorganic mercury. In Lagos, Nigeria, 77% of 440 women and men traders interviewed used skin-lightening cosmetics, and in Dakar, Senegal, 53% of 425 women interviewed used skin-bleaching agents that contained 10% mercury iodide.[14] In their self-assessment reports, Congo, Côte d'Ivoire, Gabon, Ghana, Madagascar, Mali, Mauritania, Nigeria, Tanzania, Togo and Zimbabwe indicated that mercury-contaminated soaps and skin-lightening creams were still marketed in their countries and remain significant sources of chemical exposure.

Fish: Human exposure to toxic levels of mercury from the ingestion of contaminated fish has been reported in several countries in the African Region. Elevated levels of mercury, associated with the consumption of contaminated fish from the lake, were recorded in the head hair of fishermen from around Lake Victoria in Tanzania.[18] Similar findings were obtained from the Kadoma–Chakari Region of Zimbabwe.[19] In their self-assessment reports, Côte d'Ivoire and Ghana identified ingestion of contaminated fish as a significant source of chemical exposure in their countries.

Organic mercury compounds, specifically methylmercury, concentrate in the food chain. Mercury pollution from mining is often of inorganic mercury, but aquatic organisms and vegetation in waterways such as rivers, lakes and bays convert it to methylmercury. Studies indicate that over 90% of the methylmercury fish consume is bound so tightly in their protein that even very vigorous cooking methods cannot remove it.

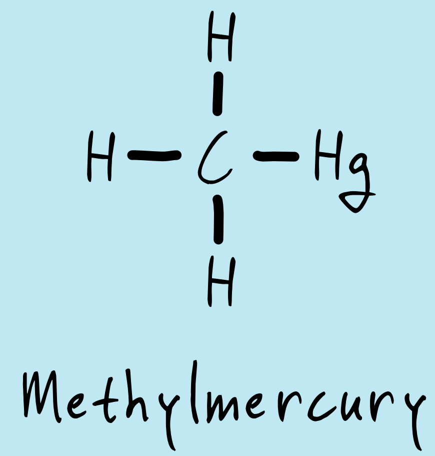
Member States reported dental amalgams, expired drugs, thermometers, batteries, mercury-based pesticides and biomass burning as likely sources of releasing mercury into the environment. For example, Burundi, Cameroon, Gabon, Lesotho and Madagascar listed dental amalgams, mercury thermometers, manometers and mercury-based drugs as significant sources of mercury exposure.

2.1.2 LEAD

Public health impact

Lead is a naturally occurring toxic metal found in the earth's crust. Its widespread use has resulted in extensive environmental contamination, human exposure and significant public health problems in many parts of the world.

Lead is one of the most dangerous chemicals to children and developing foetuses. Neurodevelopment impairment is its most critical effect. The risk of exposure to lead is especially high among young children because of their tendency to pick up particles from the ground and put them in their mouths, and due to higher levels of absorption of ingested lead compared to adults.[5,20] Lead exposure in childhood is associated with lowering intelligence quotient (IQ) scores and aggressive and violent behaviour.[21,22] Lead accumulates in the skeleton, and is passed from a mother's bones during pregnancy and lactation to foetuses and breast-fed infants. Exposure of pregnant women to high levels of lead can cause miscarriage, stillbirth, premature birth and low birth weight, as well as minor malformations in the child. Lead causes long-term harm in adults, including increasing the risk of high blood pressure and kidney damage.



Clinical features and health impacts associated with lead

Clinical features

- Acute: Excessive exposure can result in a metallic taste in the mouth, stomach pain and vomiting, diarrhoea and black stools.
- Chronic: Nausea, vomiting, abdominal pain, malaise, drowsiness, headaches, irritability, lethargy, convulsions, muscle weakness, ataxia, tremors, paralysis, and coma

Health impacts

Negative effect on brain development and, in particular, IQ scores. Aggressive and violent behaviour in children. Cardiovascular, renal and gastrointestinal effects. Haematological effects such as anaemia, adverse effects on the reproductive system (in both genders) and damage to the kidney and liver. Adverse effects during pregnancy may include impaired intrauterine growth, reduced weight and neurodevelopmental impairment.

Potential sources of exposure

The removal of lead from gasoline has perhaps been one of the greatest accomplishments in public health history and it undoubtedly produced some of the largest reductions in paediatric morbidity seen over the past 50 years.[23] Yet, despite a decline in blood lead concentration levels worldwide, lead exposure is still a major contributor to intellectual disability in children in many African countries. Exposure to lead may originate from occupational and environmental sources. In Africa, most lead in the environment comes from human activities such as mining and indiscriminate dumping and burning of lead-containing waste. Lead-based paints also are emerging as a source of lead exposure in the African Region.

Mining is a key cause of environmental lead pollution, particularly in southern Africa. For example, soil, water and air in mining areas in the city of Kabwe in Zambia have been found to be highly polluted with lead. Lead concentration levels in the soil covering approximately 21 km^2 of the city exceed the threshold of 1000 mg/kg, the level above which soil remediation is warranted.[24] As a result, lead concentrations in the blood of children living in the city exceed the recommended levels by five to 10 times.[25] High levels of lead contamination have been reported in the Natalspruit stream in Johannesburg, South Africa[26] and in streams in Zimbabwe,[27] both attributed to gold mining activities in stream or river catchment areas and to dumping waste. Rivers in the Western and Ashanti mining areas of Ghana, which are the traditional sources of drinking water, are reportedly heavily polluted with lead.[28] Extensive mining activities have been responsible for several lead poisoning incidents in the African Region. One such incident in 2010 in Zamfara, Nigeria was caused by artisanal processing of lead-rich gold ores. It resulted in the death of approximately 400 children aged 5 years and under and affected thousands of others including more than 2000 children who were left with permanent disabilities.[29,30] Such health hazards are still present in villages in which remediation has not been carried out and where children and adults continue to be exposed to lead.

Dump sites: Indiscriminate chemical waste dumping is a known practice in many parts of Africa. As a result, dump sites have become sources of exposure to toxic chemicals, including lead. For example, the Dandora dump site in Kenya is reported to be highly contaminated particularly with lead, mainly due to waste from a dry battery manufacturing plant located nearby. According to UNEP, 42% of samples collected from this site had lead levels almost 10 times higher than those of unpolluted soil. Almost 50% of students living adjacent to Dandora who were examined were found to have blood lead levels equal to or exceeding the toxicity level of 10 μg/dl.[31] The Municipal Lake in Cameroon is also reported to be highly contaminated with lead along with other heavy metals, attributed to chemical waste from various activities – including automobile servicing and battery recycling – that discharge effluents into the lake.[25]

Cultivation of food crops in contaminated dump sites is common in parts of West Africa. Small-scale farmers consider dump sites, with the apparently high organic contents of their soils, as attractive locations for high crop yields. Crops grown on such sites are highly contaminated. For instance, toxic levels of lead were detected in onions grown at the Kumasi dump site in Ghana and tomatoes grown along the Challawa River bank in Nigeria.[32,33] Elevated levels of lead have also been detected in fish caught from contaminated rivers and lakes across Africa such as from the Kafue River in Zambia, Ogba River in Nigeria and Lake Tanganyika in Tanzania.[34,35,36]

Paints: Recent studies show that concentrations of lead in paints on the market in African countries remain high despite the growing knowledge of the health effects of lead and the contribution of paint to human exposure to lead.[37,38] For instance, lead-based paints are important sources of exposure for children in the home environment because children may directly consume paint chips or dust and soil contaminated with deteriorated paint.[39,40,41]

In a 2013 UNEP-funded International POPs Elimination Network (IPEN) study, 244 cans of enamel paints purchased from nine countries including three from Africa – Côte d'Ivoire, Ethiopia and Ghana[41] – were tested for total lead content dry weight. For seven of the nine countries, including the three African states, levels of lead greater than 10 000 ppm were found in the paints. The regulatory limit for lead in paint in the United States and many European countries is 90 ppm (= mg/l). In Cameroon, 60 new locally manufactured and imported paints were analysed for lead content[42] and 40 (67%) were found to have lead concentrations greater than 90 ppm, with 39 of these exceeding 600 ppm. The highest lead concentration reported was 500 000 ppm, or 50% lead by weight, which is more than 5000 times higher than the USA standard. In a survey in Senegal, South Africa and Nigeria,[41] 18 (60%) of the 30 enamel paints tested in Senegal exceeded the lead concentrations of 90 ppm, 16 (53%) of which exceeded 600 ppm. For South Africa, of the 29 enamel paints tested, 18 (62%) had lead content exceeding 600 ppm. For Nigeria, 30 enamel and plastic paints were tested and lead concentration levels of up to 129 837 ppm were recorded (Table 1).

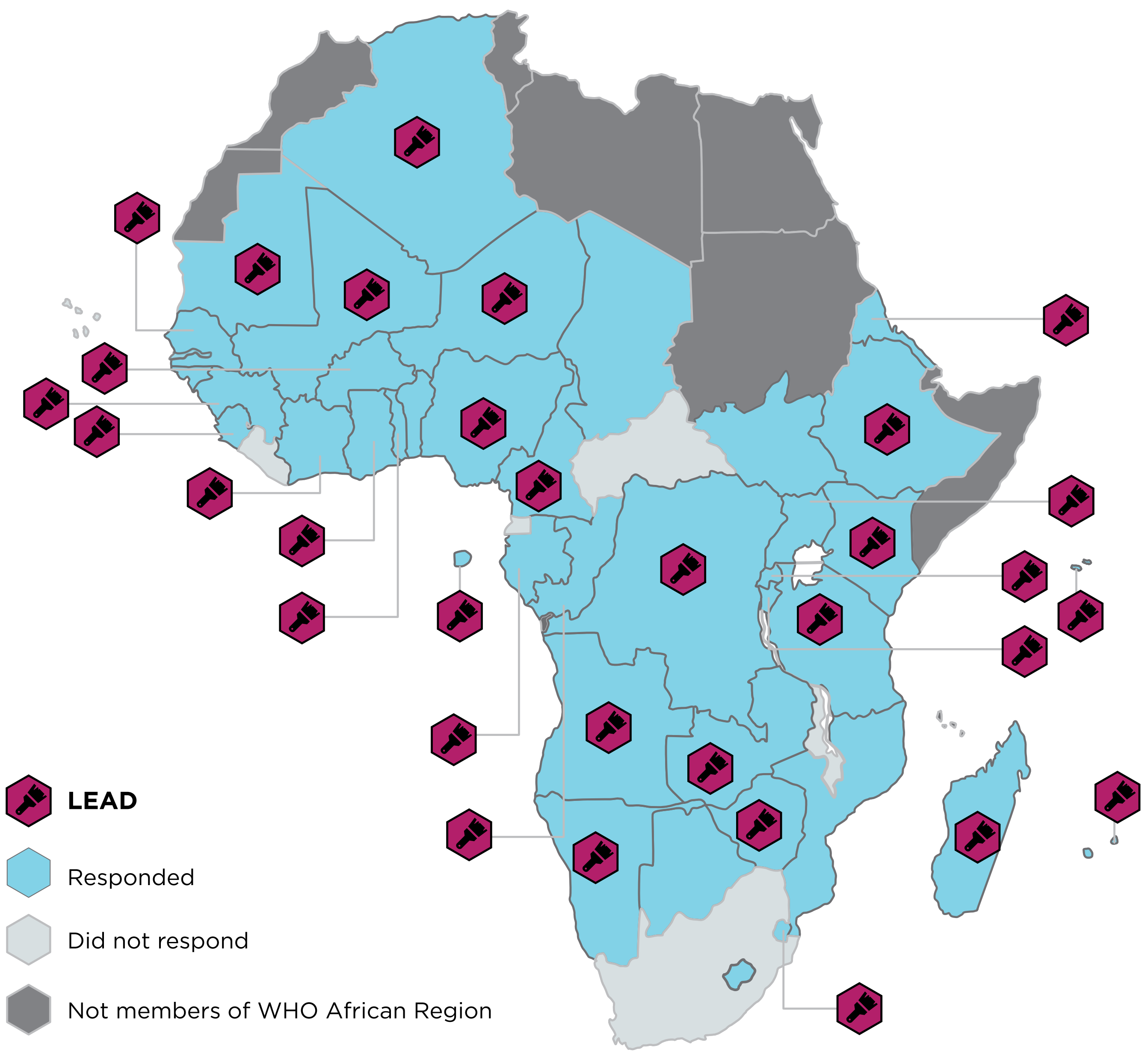
The self-assessment reports showed that paints with high levels of lead are also marketed in Gabon, Kenya, Mauritius, Swaziland, Tanzania and Zambia. Availability of paints containing extremely high levels of lead in many African countries is a serious public health issue, particularly for children's health, as these paints may be used in schools, day-care facilities and residential structures where children may be exposed to poisoning as they touch or pick up objects or put their hands or other items into their mouths.

Additional sources of lead exposure reported included the continued use of leaded petrol in Congo, Sao Tome and Principe, Sierra Leone and Zimbabwe. Furthermore, Nigeria and Togo identified toys and jewellery as potential sources of lead exposure in their countries.

Table 1: Lead in paints marketed in selected WHO African countries

Country	Cameroon	Côte d'Ivoire	Ethiopia	Ghana	Nigeria	Senegal	South Africa
Number of samples	60	20	23	18	30	30	29
> 90 ppm	67%	70%	87%	33%		60%	
> 600 ppm	65%	65%	83%	28%		53%	62%
> 10, 000 ppm	25%	25%	30%	17%			
Maximum ppm	500, 000	42, 000	130, 000	42, 000	129, 837	-	-

Figure 5: Lead as a public health concern in the WHO African Region



2.1.3 CADMIUM

Public health impact

Cadmium is an extremely toxic metal that has no known valuable function in the body and is considered more toxic than lead or mercury. Cadmium toxicity contributes to a large array of health conditions including heart disease, cancer and diabetes. The toxic effects of cadmium result primarily from inhalation of cadmium oxide fumes or dust. Cadmium oxide fumes are a pulmonary irritant.[42]

Acute exposure to cadmium mainly affects the lungs, resulting in conditions such as pulmonary irritation. Chronic inhalation of, or oral exposure to cadmium leads to a build-up of the chemical in the kidneys that can cause organ dysfunction.[43] Cadmium also concentrates in the liver and other organs. Maternal exposure to cadmium is associated with low birth weight and an increase in the likelihood of a spontaneous abortion.[44] An association between cadmium exposure from inhalation of the chemical in occupational settings and an increased risk of lung

Clinical features and health impacts associated with cadmium

Clinical features
- Acute: Flu-like symptoms including chills, fever and muscle ache sometimes referred to as “the cadmium blues”. Breathing difficulties, pulmonary oedema, abdominal pain, nausea and vomiting.
- Chronic: Loss of renal tubular function leading to proteinuria. Bronchitis, obstructive lung disease and in some cases interstitial fibrosis.

Health impacts
- Kidney damage. Emphysema of the lungs. Liver, bone, placental, brain and central nervous system toxicity. In addition, reproductive and developmental toxicity, hepatic, haematological and immunological effects. Cadmium is classified by IARC as carcinogenic in humans.

cancer has been reported in human studies.[44,45]

Many of the toxic effects of cadmium, including renal dysfunction, neurological damage, arteriosclerosis and birth defects stem from cadmium replacement of zinc in sensitive enzyme binding sites. Cadmium displaces zinc in many metallo-enzymes, and many of the symptoms of cadmium toxicity can be traced to cadmium-induced zinc deficiency.

Cadmium toxicity is increasing in incidence today for several reasons, one of which is zinc deficiency in many common foods. Zinc, which offers protection against cadmium is becoming increasingly deficient in the soil and, consequently, in foods. Iron deficiency is another reason for cadmium toxicity since dietary cadmium absorption increases when iron stores are depleted.[46] Therefore, women with nutritional deficiencies or low iron stores and foetuses and children with low body iron stores are at an increased risk of cadmium toxicity.

Sources of exposure

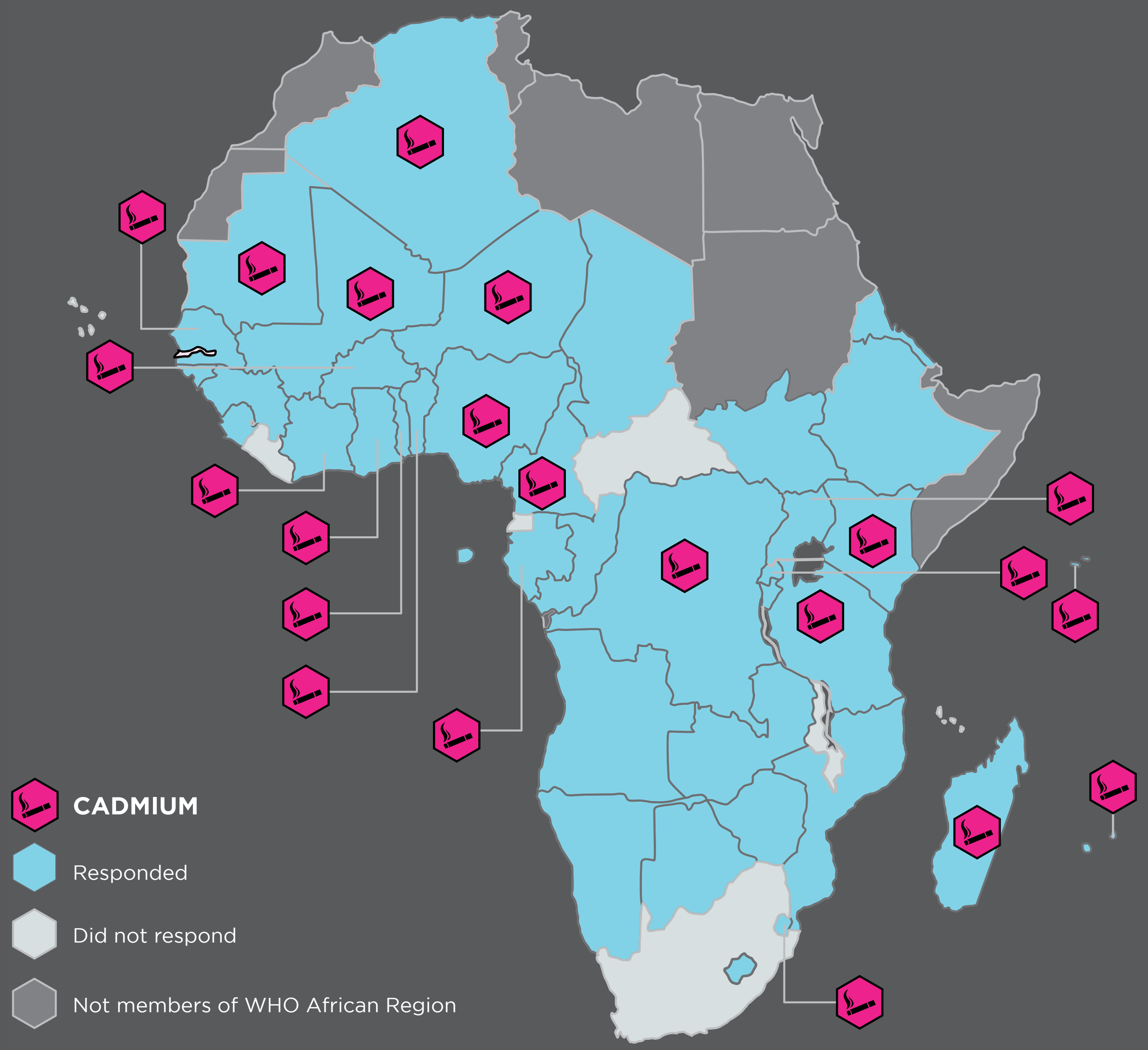
Cadmium is normally present in the environment in low levels, but human activity has greatly contributed to its current raised levels. Humans may be exposed to high levels of cadmium through the air, food or drinking water. Human exposure to cadmium in Africa is thought to be mainly due to consumption of contaminated crops and vegetables and tobacco smoking.

Cadmium accumulates in the soil via several routes. Long-term use of phosphate fertilizers, micronutrients and sewage sludge increases the levels of cadmium, as well as arsenic and lead, in crop soils.[47] Disposal of untreated sewage and discharge of industrial effluent also contaminate the soil and water bodies. In Africa, there are reports of cadmium contamination in soil and water body sediment resulting from industrial activities. For example, highly toxic levels of cadmium were recorded in the sediment of Municipal Lake in Cameroon.[25] Additionally, industrial waste discharge is associated with the high cadmium contamination of Sorowie and Kakum rivers in Ghana[29] and the extensive cadmium contamination of the soil in Ikeja Industrial Estate area in Lagos, Nigeria, during the rainy season.[48]

Food: As a result of extensive soil and water contamination, toxic levels of cadmium are taken up by certain crops and aquatic organisms and accumulated in the food chain.[49] Consumption of cadmium-contaminated food can have detrimental effects on human health.[50] The literature has many reports of human exposure to cadmium through ingestion of contaminated crops and fish. For example, high levels of cadmium contamination were reported in lettuce grown by irrigation using water from Akaki River in Ethiopia,[51] cabbage grown at the Kumasi waste dump sites in Ghana,[33] tomatoes grown along the Challawa River bank in Nigeria,[33] vegetables cultivated along the Sinza River in Tanzania,[52] edible vegetables grown in polluted roadside soils in Uganda,[53] and a locally consumed vegetable (tsunga) in Harare, Zimbabwe.[54] In the Democratic Republic of the Congo, the population of Katanga is reportedly substantially exposed to cadmium through contaminated locally grown vegetables and locally caught fish.[55]

Tobacco: Smoking tobacco is an important risk factor, since the tobacco plant naturally accumulates relatively high concentrations of cadmium in its leaves.[56] Cigarettes are especially dangerous because cadmium is absorbed more efficiently when inhaled. The amount of cadmium inhaled from smoking one cigarette containing about 1.7 µg of cadmium has been estimated to be 0.14 to 0.19 µg, which is about 10% of the total cadmium content of the cigarette.[57]

Figure 6: Cadmium as a public health concern in the WHO African Region



2.1.4 ARSENIC

Public health impact

Arsenic is highly toxic in its inorganic form. It is rarely found as a free element in the natural environment, it exists more commonly as a component of sulphur-containing ores in which it occurs as metal arsenides.

Arsenic exposure induces cardiovascular diseases, developmental abnormalities, neurological and neurobehavioural disorders, diabetes, hearing loss and haematological disorders.[58] Long-term consumption of arsenic-contaminated water leads to serious health effects often referred to as arsenicosis. The features of arsenicosis manifest after several years of exposure, initially as skin lesions, which then progress into localized gangrene and eventually into cancers of the skin, lung, bladder or kidneys.[59]

Clinical features and health impacts associated with arsenic

Clinical features

- Acute: Vomiting, oesophageal and abdominal pain, heart failure, garlic breath, and bloody diarrhoea. Non-specific symptoms related to the respiratory tract and endocrine system.
- Chronic: Skin pigmentation changes, skin lesions and hard patches on the palms and soles of the feet (hyperkeratosis). These may be precursors of skin cancer.

Health impacts

- Cardiovascular diseases, developmental abnormalities, neurological and neurobehavioural disorders, diabetes, hearing loss, haematological disorders and various types of cancer.

Potential sources of exposure

Arsenic is widely distributed in natural bodies of water and is often associated with particular geological sources, but in some locations anthropogenic inputs such as arsenical insecticides and combustion of fossil fuels can be extremely important sources of additional arsenic.

Human beings may be exposed to arsenic from many sources including air, water, soil and food. Smoking tobacco is also an important source of exposure to the natural inorganic arsenic in tobacco because tobacco plants take up arsenic present in the soil.[61] However, the greatest threat to public health from arsenic originates from contaminated groundwater, which may be a result of natural geochemical processes or anthropogenic pollution.

Drinking water: Arsenic concentrations in drinking water above accepted standards have been reported in many countries on all continents, and should therefore be regarded as a global public health issue. In Africa, arsenic levels that exceed acceptable standards set by WHO have been reported in drinking water in a number of countries including Botswana, Burkina Faso, Cameroon, Ethiopia, Ghana and Nigeria (Table 2). In a study in northern Nigeria, the mean arsenic concentration in water samples collected from wells and boreholes exceeded the WHO guideline value of 0.01 mg/l by 28 times and 9 times, respectively.[62] These elevated arsenic concentrations were attributed to both natural and anthropogenic processes such as erosion, under-surface weathering, improper waste and sewage disposal, agricultural activities and vehicular emissions. Highly elevated levels of arsenic have been reported in streams and rivers in Tarkwa and the Ashanti gold belt in Ghana, associated with anthropogenic activities, mainly artisanal mining.[63] Table 2 shows some locations in the WHO African Region with confirmed arsenic contamination of drinking water.

High concentrations of arsenic have been detected in imported and locally manufactured beverages and fruit juices commonly sold in Nigeria. According to one study, of 50 beverages sampled in Nigeria, 21 of which were canned and 29 uncanned, seven (33.3%) of the canned beverages and 16 (55.2%) of the uncanned beverages exceeded the guideline value of 0.01 mg/l set by WHO.[64]

Elevated levels of arsenic in groundwater have been reported in the African Region (Figure 7). Moreover, hydrogeological studies indicate that other African countries, including Algeria, Angola, Benin, Burundi, Central African Republic, Chad, Congo, Côte d'Ivoire, Eritrea, Gabon, Lesotho, Mozambique, Namibia, Senegal, Sierra Leone, South Africa and Zimbabwe have a risk of arsenic pollution of drinking water.[65]

Figure 7: Countries reporting arsenic in the WHO African Region

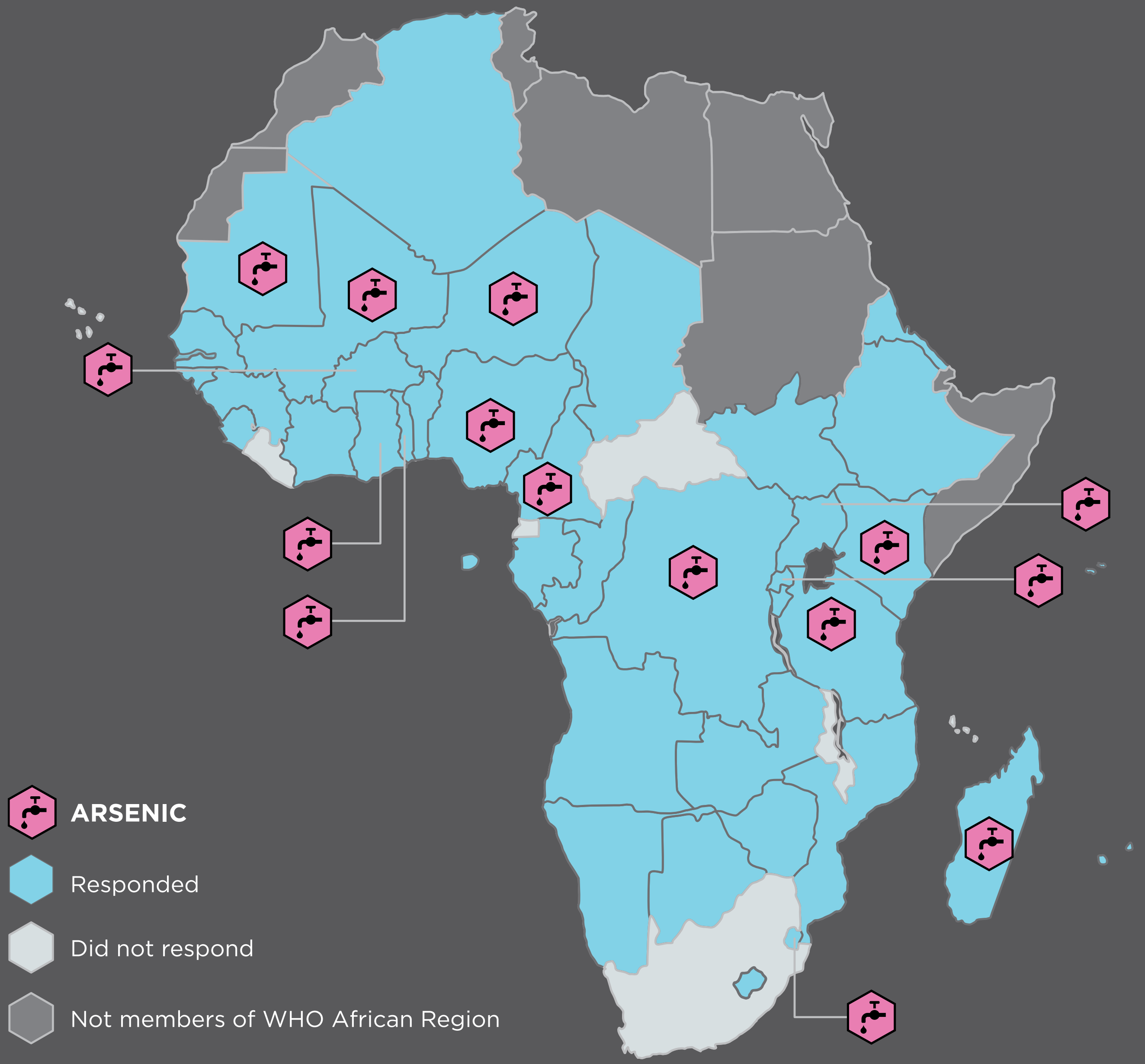


Table 2: Arsenic contamination of groundwater in the WHO African Region

Country	Location
Botswana	Okavango Delta
Burkina Faso	Yatenga
Cameroon	Ekondo Titi
Ethiopia	Rift Valley
Ghana	Offin and Ankobra basins
Nigeria	Kaduna, Ogunstate, Rivers State and Wari in Port Harcourt

2.2 FLUORIDE

Public health impact

Fluoride has both beneficial and detrimental effects on human health. The beneficial effects are limited to levels of about 1 mg/l in potable water,[66] levels at which fluoride reportedly improves skeletal and dental health. Nonetheless, as far as acute exposure is concerned, fluoride is more toxic than lead but slightly less toxic than arsenic.

High or low fluoride levels in drinking water are associated with adverse health effects.[67,68] The prevalence of dental caries is inversely related to the concentration of fluoride in drinking water, while a dose-response relationship exists between the concentration of fluoride in drinking-water and the prevalence of dental fluorosis.[69] In terms of general health, skeletal fluorosis and bone fractures are the adverse health effects most commonly reported by communities whose drinking water and food are excessively high in fluoride. Moreover, exposure to high levels of fluoride has also recently been associated with neurological damage in children.[70]

Potential sources of exposure

Excessive fluoride intake usually results from consumption of groundwater naturally rich in fluoride or crops that take up fluoride that have been irrigated with such water. Groundwater with high fluoride concentrations exists in many areas of the world including several parts of Africa. One of the best known high fluoride belts on land extends

Clinical features and health impacts associated with fluoride

Clinical features

- High concentrations: Abdominal pain, excessive saliva, nausea and vomiting. Seizures and muscle spasms may also occur. Early symptoms of skeletal fluorosis include stiffness and joint pain. In severe cases, the bone structure may change and ligaments may calcify resulting in muscle impairment and pain.
- Low concentrations: Dental caries.

Health impacts

- High concentrations: Neurological damage. Reduced IQ scores in children. Dental and skeletal fluorosis. Associated with osteosclerosis, calcification of tendons and ligaments and bone deformities, tooth mottling.
- Low concentrations: Tooth decay and fractures.

along the East African Rift from Eritrea to Malawi. High concentrations of fluoride in groundwater associated with certain granites and gneisses rock types have also been reported in west and southern Africa including in Niger, Senegal and South Africa.

Drinking water: According to a 2006 study conducted in Ethiopia, 41% of the drinking water sources in the Ethiopian Rift Valley had fluoride levels exceeding the WHO 2008 guideline value of 1.5 mg/l.[71] The highest concentration reported was 36 mg/l. In another study, in which samples were collected from 12 wells that were frequently used by residents of the Main Ethiopian Rift for drinking, fluoride concentrations exceeded the WHO guideline value by 5 to 12 times.[72] An estimated 8 million people living in the Main Ethiopian Rift were reported to be at risk. In Tanzania, fluoride concentrations of up to 45 mg/l have been detected in groundwater in the Rift Valley, and dental and skeletal fluorosis are commonly reported in areas with naturally high concentrations of fluoride in drinking water sources. In a survey in Kenya, 20% of 1000 samples collected from locations covering the whole country had fluoride levels greater than 5 mg/l, of which 12% exceeded 8 mg/l. The highest fluoride concentrations, ranging from 30 mg/l to 50 mg/l, were reported in groundwater from the volcanic areas of the Nairobi, Rift Valley and Central provinces.[73] A survey of fluoride in groundwater in southern Malawi was undertaken, and the areas found to be the most affected included Songwe, Nkhotakota Boma and Mazengera.[74,75] Songwe had the highest fluoride concentration at 9.6 mg/l. In South Africa, high fluoride levels in drinking water have been reported from the North West province, the Karoo, Limpopo and Northern Cape, with fluoride levels of up to 13 mg/l detected[76] (see Table 3), bearing in mind that ingestion of water with fluoride levels above 1.5 mg/l has negative impacts on health.

Fluoride levels are naturally low in countries in Africa such as South Africa and Nigeria, where low levels have been recorded in many subregions.[77] A 2009 study in Nigeria found that about 21% of water sources were naturally fluoridated to the range of 0.3–0.6 ppm, about 62% had fluoride levels below this range and 17% above this range.[78] The recommended WHO guideline for minimum values of fluoride in drinking water is 0.5 mg/l.[78]

Food: Although drinking water is the largest source of daily fluoride intake, children are also exposed to excess fluoride through food, as high amounts of fluoride are retained in food prepared with highly fluoridated water.[79,80] Furthermore, exposure to lead may exacerbate fluoride toxicity.[81,82]

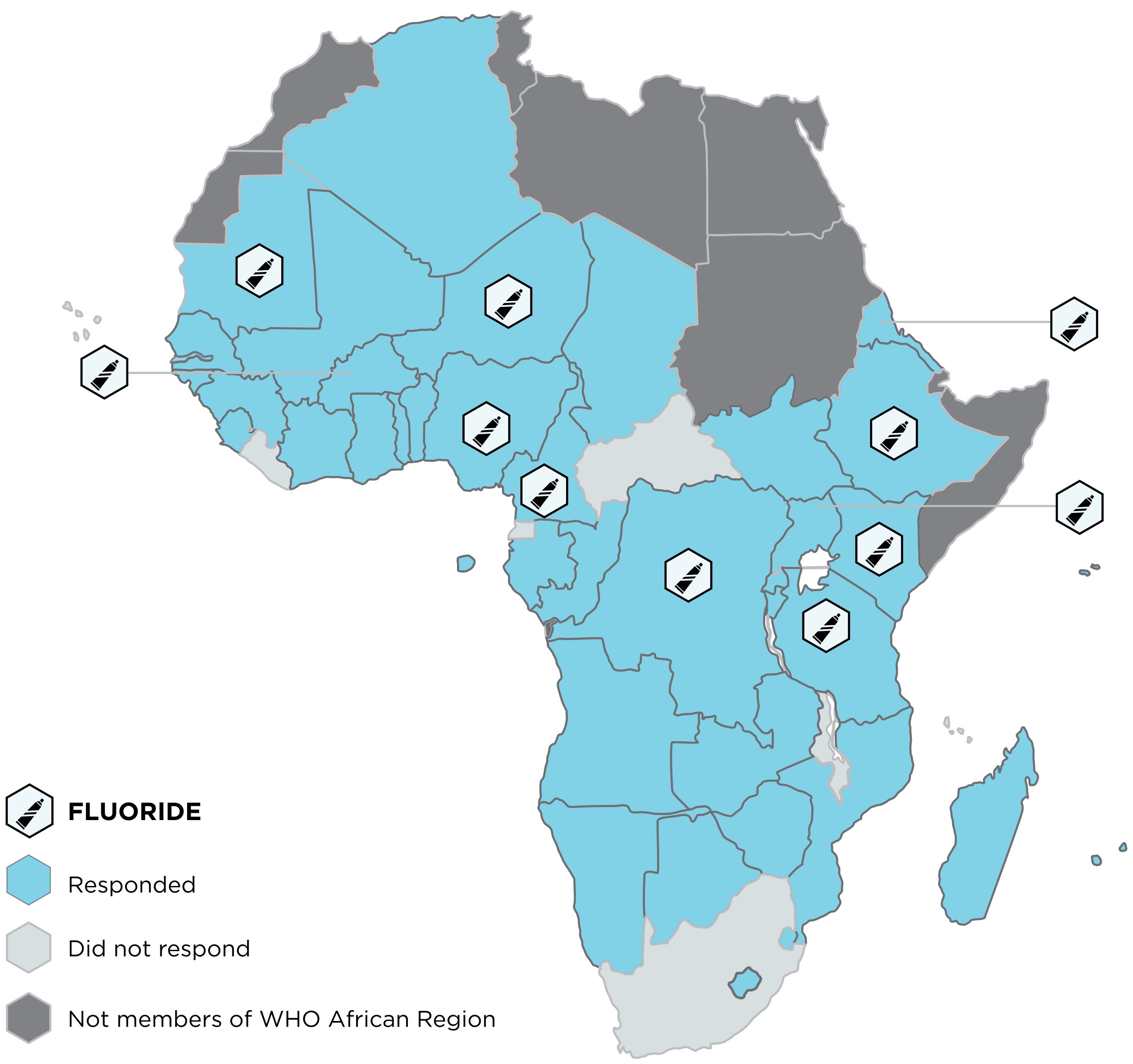
Figure 8 shows the countries in the African Region that reported fluoride levels as a health concern.

Table 3: Fluoride levels in drinking water in some countries of the WHO African Region

WHO recommended level = 1.5 mg/l

Maximum fluoride concentration reported (mg/l)	Country / area
36 mg/l	**Ethiopia** Rift valley
45 mg/l	**Tanzania** Rift valley
50 mg/l	**Kenya** Nairobi, Rift Valley and Central provinces
9.6 mg/l	**Malawi** Songwe, Nkhotakota Boma and Mazengera
13 mg/l	**South Africa** Karoo, Limpopo and the Northern Cape

Figure 8: Fluoride as a public health concern in the WHO African Region



2.3 CYANIDE

Public health impact

Cyanide is acutely toxic to humans. Liquid or gaseous hydrogen cyanide and alkali salts of cyanide can enter the body by inhalation, ingestion or absorption through the eyes and skin. The toxicity of cyanide to humans is dependent on the nature of exposure. Inhaled salts of cyanide are readily dissolved and absorbed upon contact with the moist mucous membranes. Symptoms and signs of cyanide poisoning usually occur less than one minute after cyanide inhalation and within a few minutes after ingestion. Early manifestations of cyanide toxicity include anxiety, headache, giddiness and mydriasis, and as hypoxia progresses, gradually lower levels of consciousness, seizures and coma will occur.

Studies indicate that in African countries where cassava is an important staple food, ingestion of poorly processed cassava root is associated with ataxic neuropathy (konzo).[83] People consuming poorly processed cassava in large quantities are susceptible to neuropathologies caused by cyanide. Where cassava-based diets are not supplemented with good sources of protein and iodine, goitre and rickets also are prevalent.[84] Certain African countries with high rates of ataxic neuropathy reported the incidence of thyroid disorders also to be high.

Clinical features and health impacts associated with cyanide

Clinical features

- Dizziness, headache, confusion, nausea, vomiting, stomach pains, diarrhoea, dyspnoea, fatigue, mydriasis and seizures.

Health impacts

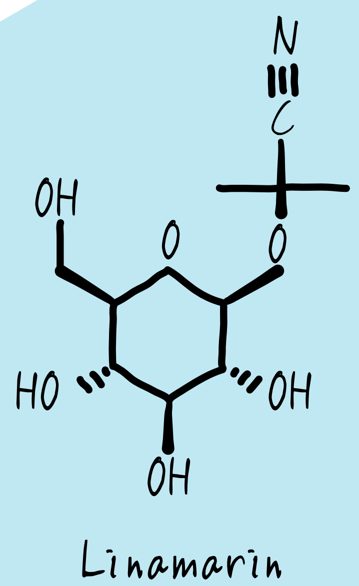
- Liver and kidney damage and goitre and thyroid disorders. Ataxic neuropathy (konzo), associated with ingestion of poorly processed cassava root.

Potential sources of exposure

In Africa, human exposure to cyanide has two main sources: food plants naturally rich in cyanide and contamination of air, soil and water with cyanide associated with industrial activities, principally mining.

Food: Cyanogenic glycosides occur in many food plants such as cassava, lima beans and the seeds of some fruits such as peaches. Because of this, ingestion of large amounts of cassava and lima beans can be fatal if they are eaten raw or are not prepared correctly. The cassava plant is by far the most important source of cyanide in human food. Cassava toxicity is reduced a great deal by peeling, washing in running water to remove the cyanogen, and then cooking or fermenting it to inactivate the enzymes and to volatilize the cyanide. However, studies indicate that the linamarin content of cassava, the chemical responsible for cassava poisoning, more than doubles during drought.

Cassava toxicity is the main risk factor for the disease known as "konzo".[85] Konzo is an upper motor neurone disease with a sudden onset,[86,87,88] common in eastern, southern and central Africa that causes irreversible paralysis of the legs, particularly in children and women of childbearing age. A 2008 study estimated the number of cases of konzo in Angola, Mozambique, the Democratic Republic of the Congo, Congo and Ghana to be about 100 000.[89]

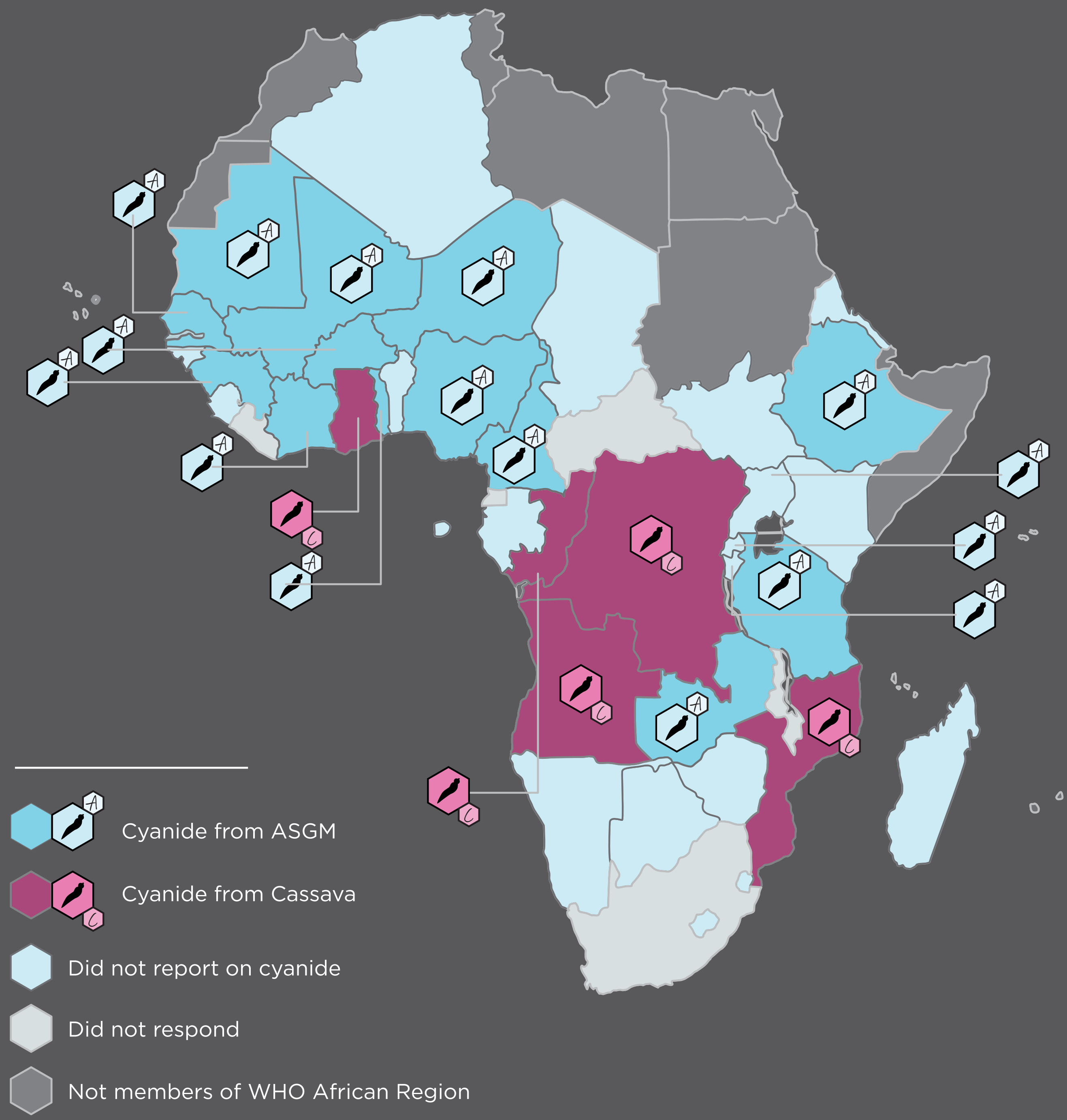


Konzo, which is reportedly more prevalent following droughts or wars, has claimed many lives.[90,91,92] For example, thousands of cases of konzo were reported in the Democratic Republic of the Congo following the five-year civil war that forced people to eat wild bitter cassava roots without proper processing. In Mozambique, an outbreak of konzo in Nampula and Zambezia provinces following a drought in 2005 resulted in more than 100 cases.[93] Outbreaks of the disease have also been reported from Tanzania, Cameroon, Central African Republic and other countries.[90]

Occupational exposure: Cyanide is used in various occupational settings including certain metal-mining processes, metal cleaning, electroplating, metallurgy, some types of pesticide application, tanning, photography and photoengraving, and dying and pharmaceutical processes.[94] In Africa, the use of cyanide in gold mining is by far the most important source of occupational exposure. The most commonly used process for gold extraction is hydrometallurgical recovery (gold cyanidation), which involves a "leaching" step during which the gold is dissolved in an aqueous cyanide medium before separation of the gold-bearing solution from the residues. The purpose of adding sodium cyanide into the amalgamation medium is to clean the gold surface and improve amalgamation. During this process, hydrogen cyanide (HCN) gas, which is extremely poisonous, is produced and released into the environment.

In their reports, 13 of the 40 Member States participating in this study (Figure 9) indicated that cyanide was used widely by their artisanal small-scale gold miners in the gold amalgamation and purification processes, and that this caused extensive occupational health problems.

Figure 9: Cyanide as a public health concern in the WHO African Region



2.4 AIR POLLUTANTS

Air pollution is a major environmental health problem affecting both developed and developing countries. Air pollution encompasses both indoor and outdoor air quality. Indoor air pollution usually results from the burning of wood, coal or paraffin for space heating, cooking and lighting purposes. Outdoor air pollution is largely a consequence of fossil fuel combustion for transport and electricity generation, industrial non-fossil fuel emissions and other human activities.

Air pollutants may be grouped into four categories:
(a) gaseous pollutants such as sulphur dioxide, carbon monoxide and ozone
(b) persistent organic pollutants such as dioxins and furans
(c) heavy metals such as lead, mercury and arsenic
(d) particulate matter of various sizes, e.g. $PM_{2.5}$ and PM_{10}

Public health impact

The public health impact of exposure to air pollutants is too complex to determine because there are many sources of pollutants and their individual effects vary. Exposure to air pollutants, particularly from combustion of solid fuels used in households, has been implicated with varying degrees of evidence as a causal agent in a number of diseases in developing countries including acute respiratory infection, otitis media, chronic obstructive pulmonary disease (COPD), lung cancer, asthma, nasopharyngeal and laryngeal cancer, tuberculosis, perinatal conditions and low birth weight, and eye diseases such as cataracts and blindness.[95,96] Exposure to air pollution causes an estimated 4.5% of the global burden of disease. More than one third of all child deaths caused by indoor air pollution occur on the African continent.[97]

Clinical features and health impacts associated with fluoride

Clinical features

- Acute: Conjunctival hyperaemia, respiratory disorders and nausea.
- Chronic: Chronic cough, bronchitis, COPD, exacerbation of asthma and lung cancer.

The health impacts associated with some specific chemical pollutants are described below.

Health impacts

- Increased risk of haematological disorders, ischaemic heart diseases; carcinoma of the trachea, bronchus and lung; chronic lower respiratory disease; and cerebrovascular disease. Digestive disorders, skin diseases, rheumatic and nervous conditions, hearing and visual disorders. Air pollution has also been linked to cognitive decline in older people.

Potential sources of exposure

The highest levels of air pollutants to which people are exposed in Africa are in the indoor environment. Inhalation is the primary route of exposure, but airborne pollutants may also be deposited on soil, plants and in water, which serve as indirect exposure routes.

Solid fuels: Solid fuels are the main source of indoor air pollution in Africa. Nearly 3 billion people worldwide and a great majority of households in developing countries rely on solid fuels such as wood, dung, crop residues, coal and charcoal for cooking and other household energy needs and have little or no access to modern fuels.[98,99] Incomplete combustion of solid fuels in inefficient, poorly vented combustion devices such as open fires and traditional stoves results in much of the fuel energy being emitted as potentially toxic pollutants, including particles of varying sizes, carbon monoxide, nitrogen dioxide, volatile and semi-volatile organic compounds such as formaldehyde and benzo[a]pyrene, methylene chloride, and dioxins.[100] Combustion of coal, in addition to generating these pollutants, releases sulphur oxides and heavy metals such as arsenic and fluorine.[101] Indoor smoke from solid fuels is the second most important environmental cause of disease after contaminated water, and more than one third of all child deaths caused by indoor air pollution occur on the African continent.[98] The proportion of the African population exposed to indoor air pollutants from solid fuels is shown in Figure 10.

Land transport has emerged as a major source of outdoor air pollution in many parts of Africa. With population growth and rapid urbanization, land transport has increased tremendously but without adequate controls or inspection procedures for automobile exhaust gases.[103] Quantitative data on the impact of automobile emissions on outdoor air quality is limited because air

Table 4: Public health impacts of common chemical contaminants in air

Air pollutant	Health impact
Particulate matter	■ The particles can become embedded in the deepest recesses of the lung and can also disrupt cellular processes. ■ Can induce systemic inflammatory changes, affecting blood coagulation. ■ A strong link has been reported between elevated levels of particulate matter in the air and premature deaths and asthma attacks.
Carbon monoxide	■ Binds to haemoglobin, modifying its conformation and reducing its capacity to transfer oxygen. Reduced oxygen availability can affect the function of different organs, especially high oxygen-consuming organs such as the brain and the heart, resulting in impaired concentration, slow reflexes and confusion.
Sulphur dioxide	■ Can cause respiratory illness and aggravation of heart disease. ■ Is associated with diseases of the lung and other lung disorders such as airway obstruction
Nitrogen oxide	■ Reacts with ammonia, moisture and other compounds to form small particles that can penetrate deeply into the lungs, causing or worsening respiratory diseases, such as emphysema and bronchitis, and that can exacerbate heart disease, leading to increased hospital admissions and premature death. ■ Renders children susceptible to respiratory diseases.
Ozone	■ Causes eye irritation. It has also been associated with increases in respiratory disorders such as asthma. Ozone lowers our resistance to colds and pneumonia.
Dioxins	■ Cause neurotoxicity, decreased nerve conduction velocity, impaired mental development in children, ischaemic heart disease, and gastrointestinal and liver cancer.
Lead	■ Prolonged exposure to lead can cause neurotoxicity and digestive problems. Lead is especially hazardous to small children.
Volatile organic compounds	■ Cause irritation of the eyes, nose and throat. In severe cases there may be headaches, nausea and loss of coordination. Long-term exposure may result in damage to the liver and other organs.
Tobacco smoke	■ Carcinogenic in active smokers, in passive smokers it can cause irritation of the eyes, nose and throat. It is associated with cancer, bronchitis, severe asthma and a decrease in lung function.
Formaldehyde	■ Causes irritation of the eyes and nose and allergies in some people.
Radon (radio-active gas)	■ Increases the risk of lung cancer.

quality studies are not routinely conducted. The few studies that have been conducted in Africa show that some communities or populations are exposed to levels of air pollutants that exceed recommended limits. For example, according to a study conducted in 2009 in Kenya, mean daytime concentrations of traffic-related particulate matter ($PM_{2.5}$) in and around Nairobi City ranged from 10.7 $\mu g/m^3$ on a rural background site to 98.1 $\mu g/m^3$ on a sidewalk in the central business district.[104] Particulate matter is a major component of outdoor air pollution and is widely used as a health-relevant indicator of air quality. Fine particles, usually referred to as $PM_{2.5}$, are a major concern. Though not directly comparable to air quality guidelines, which are based on 24-hour or annual averages, the study noted that Nairobi residents were exposed, on a regular basis, to toxic levels of fine particulate matter with potentially serious long-term implications for their health.

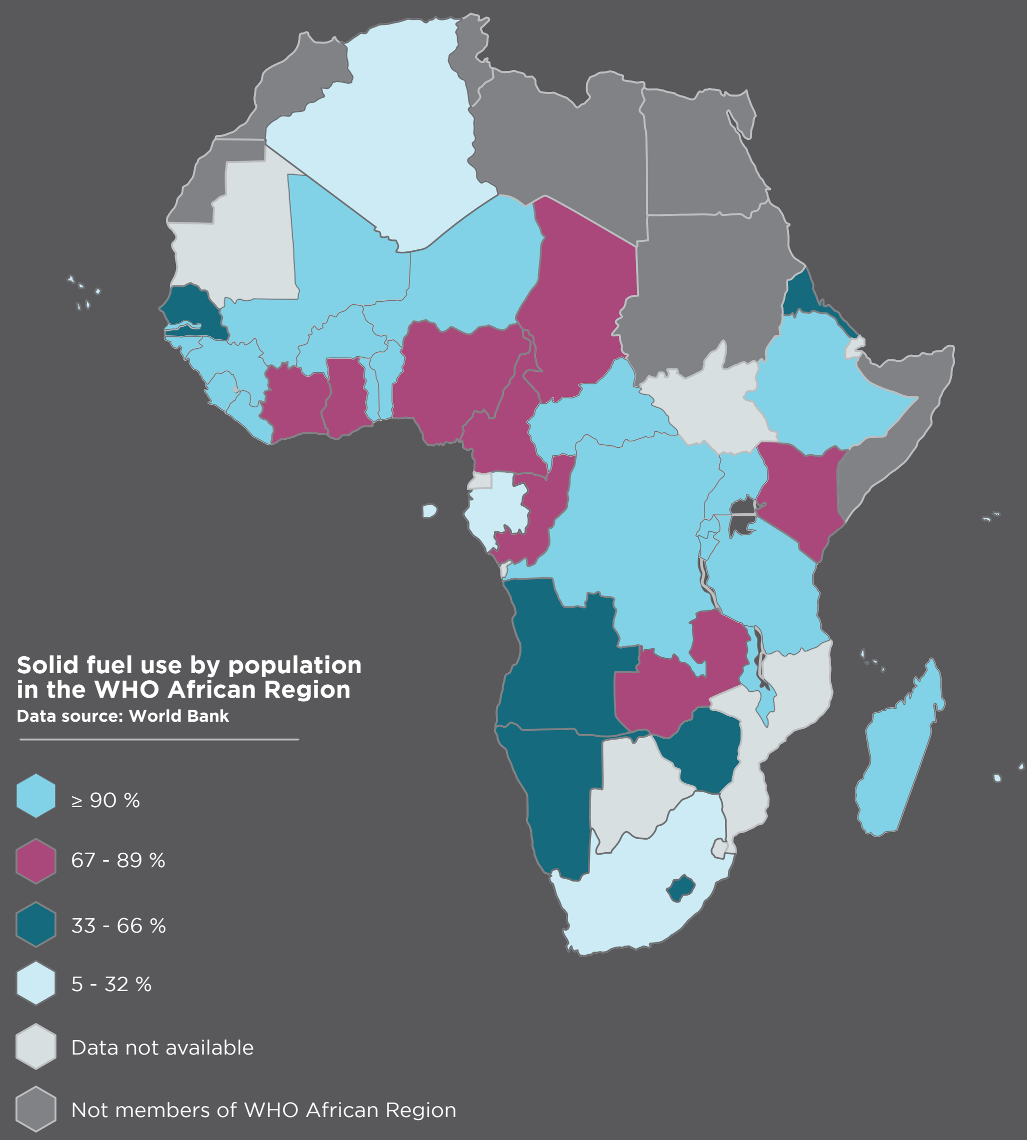
A survey conducted in 2005 in Dar-es-Salaam, Tanzania, monitoring hourly mean sulphur dioxide concentrations in eight locations in the city found seven of the locations had sulphur dioxide concentrations exceeding the 1987 WHO guideline limit of 350 $\mu g/m^3$.[105] The highest concentration was 1385 $\mu g/m^3$, which correlated to high levels of vehicular emissions.

Industrial activity is an important contributor to outdoor air pollution in the Region; however, air quality issues in affected areas are typically sector specific aside from those related to long-range transport - for example, in regions that are heavily involved in natural resource mining,[106] the impact of that sector on ambient air quality can be significant in communities engaged in mining and processing activities. Table 5 lists some common atmospheric pollution sources and their pollutants.

Table 5: Common air pollution sources and emitted pollutants

Category	Source	Pollutants emitted
Agriculture	Open burning	Dioxins, furans, PCBs, particulate matter, carbon monoxide, volatile organic compounds
Mining and quarrying	Coal mining, crude oil and gas production, stone quarrying	Particulate matter, sulfur dioxide, nitrogen oxide, volatile organic compounds
Power generation	Electricity, gas, steam generation	Particulate matter, sulfur dioxide, nitrogen oxide, carbon monoxide, volatile organic compounds, sulfur trioxide, lead
Transport	Combustion engines	Particulate matter, sulfur dioxide, nitrogen oxide, carbon monoxide, volatile organic compounds, lead
Health	Incinerators	Particulate matter, sulfur dioxide, nitrogen oxide, carbon monoxide, volatile organic compounds, heavy metals
General	Burning of waste such as plastics	Dioxins, furans, PCBs, particulate matter, carbon monoxide, sulfur dioxide, nitrogen oxide, volatile organic compounds, heavy metals

Figure 10: Exposure to indoor air pollutants in the WHO African Region



2.5 BENZENE

Public health impact

Human exposure to benzene has been associated with a range of acute and long-term adverse health effects and diseases. Acute exposure to benzene may cause narcosis, headache, dizziness, drowsiness, confusion, tremors, irritation and loss of consciousness. Use of alcohol enhances the toxic effect of benzene.[107] Chronic exposure to benzene has been reported to result in bone marrow depression, aplasia and leukaemia, cardiac abnormalities, myocardial ischaemia, and cancers of the lung, brain and stomach.[108] Benzene can also cause excessive bleeding and can affect the immune system, increasing the risk of infection. Long-term exposure to benzene has also been associated with reproductive disorders in women.

Clinical features and health impacts associated with benzene

Clinical features

- Acute: Excitement, nausea, respiratory irritation, headache, drowsiness, incoherent speech and flushed face. Rapid or irregular heartbeat, vomiting, gastric irritation, and convulsions.

Health impacts

- Acute: Anaemia, acute myelogenous leukaemia, acute myeloid leukaemia, and acute lymphocytic leukaemia.
- Chronic: Haematological disturbances, bone marrow deficiency, aplastic anaemia and leukaemia. Immunotoxicity and reproductive disorders in women.

Potential sources of exposure

Exposure to benzene can occur from occupational or domestic activities because of the widespread use of benzene-containing petroleum products such as motor fuels and solvents and studies indicate that benzene occurs in higher concentrations in poorer quality gasoline. Benzene is found in the air due to emissions from coal and oil burning, benzene waste and storage operations, motor vehicle exhaust, and gasoline evaporation at service stations. Tobacco smoke also is a significant source of benzene in the air, particularly indoors. Benzene is highly volatile, and exposure to it occurs mostly through inhalation.

Exposure to harmful hydrocarbons, including benzene and polycyclic aromatic hydrocarbons (PAHs), has been reported in a number of countries in the African Region. For example, a biomonitoring study conducted in Kinshasa, Democratic Republic of the Congo, determined benzene concentrations in blood by measuring S-phenylmercapturic acid (S-PMA) in spot urine samples from 220 individuals (of whom 111 were female) aged 6–70 years living in the urban area and 50 others from sub-rural area of the city.[109] The urban area had high levels of population density, motorization, old vehicles and car traffic, whereas the sub-rural area had a higher percentage of green areas.[110] Higher levels of S-PMA in urine, correlating with the high levels of benzene in blood, were detected in the urban population of Kinshasa compared with the sub-rural population. S-PMA is a minor metabolite of benzene excreted in urine and has been recommended as a suitable biomarker for monitoring benzene exposure in environmental and occupational settings. The study recommended that the high level of benzene exposure of the Kinshasa population required determination of the chemical's concentrations in ambient air and setting limits for the protection of human health. A study in Cotonou, Benin (a city where two-stroke motorbikes are the major form of transportation and where gasoline quality is poor), assessed exposure to benzene and PAHs in ambient air using personal monitoring and biomarkers.[111] Non-smoking taxi-moto drivers, representing city dwellers, and village residents were the study subjects. Benzene exposure in the city was found to exceed the WHO maximum limit of 5 µg/m^3 by more than 15 times, but in the village the level was only 3.4µg/m^3. Urinary excretion of total PAHs also was higher in subjects living in the city.

Petrochemical spills resulting from petroleum extraction activities are significant sources of benzene exposure, particularly in West Africa. Such spills not only contaminate surface water and groundwater but also pollute the ambient air and crops with hydrocarbons, including known carcinogens such as benzene and PAHs. For example, the Niger River Delta of Nigeria, which was ranked among the top 10 toxic threats in 2013 by the Blacksmith Institute,[112] is heavily polluted by oil and hydrocarbons because it has been the site of major petroleum operations since the late 1950s. According to estimates, over 4000 spill incidents have occurred in Nigeria since 1960, resulting in the release of over 2 million barrels of crude oil into the environment.[113] These spills have affected the health of the local population in a number of ways, since crude oil is haemotoxic and may cause infertility and cancer. Widespread pollution in the Niger Delta could lead to a 60% reduction in household food security and a 24% increase in the prevalence of childhood malnutrition.[114]

Occupational exposure to benzene is very common in Africa. Automobile mechanics and petrol station attendants are at a special risk mainly because they lack proper guidance on and adherence to safety procedures. For example, a study in Calabar, Nigeria, that investigated the potential risk of exposure to benzene from petrol among automobile mechanics and petrol station attendants[115] found that mechanics often exposed themselves to benzene when they used their mouths to suck petrol through a tube to siphon it from vehicle tanks. In addition, they cleaned vehicle parts using petrol without gloves. Petrol station attendants were found to dispense fuel into vehicles without protective gear to minimize their exposure. Such practices are very common in many parts of Africa and raise serious public health concerns. In self-assessment reports, the Member States shown in Figure 11 listed benzene as one of the chemicals of public health concern.

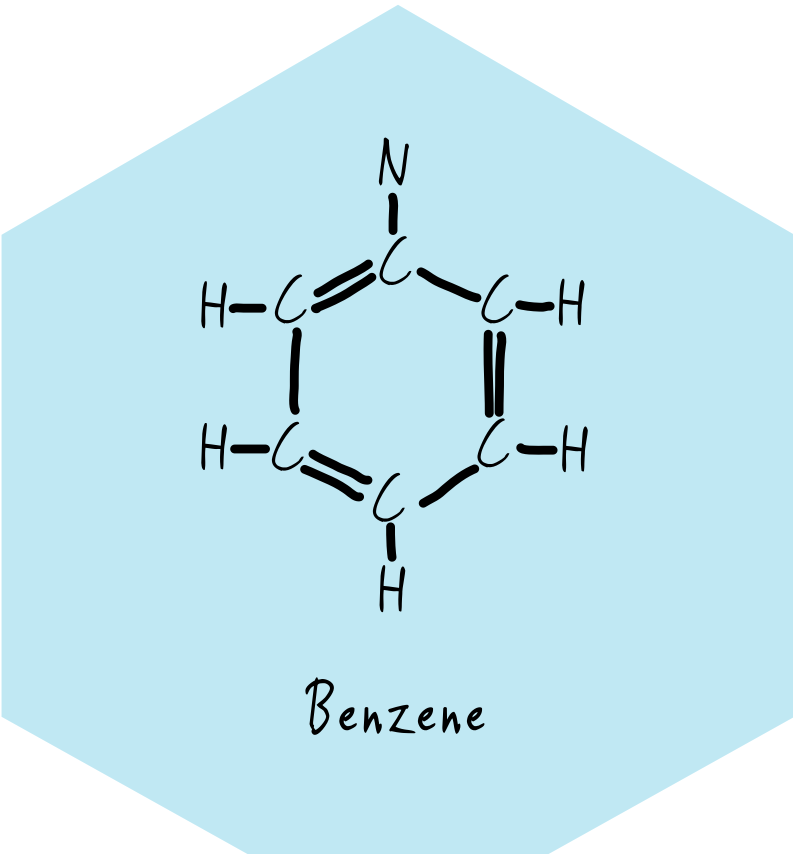
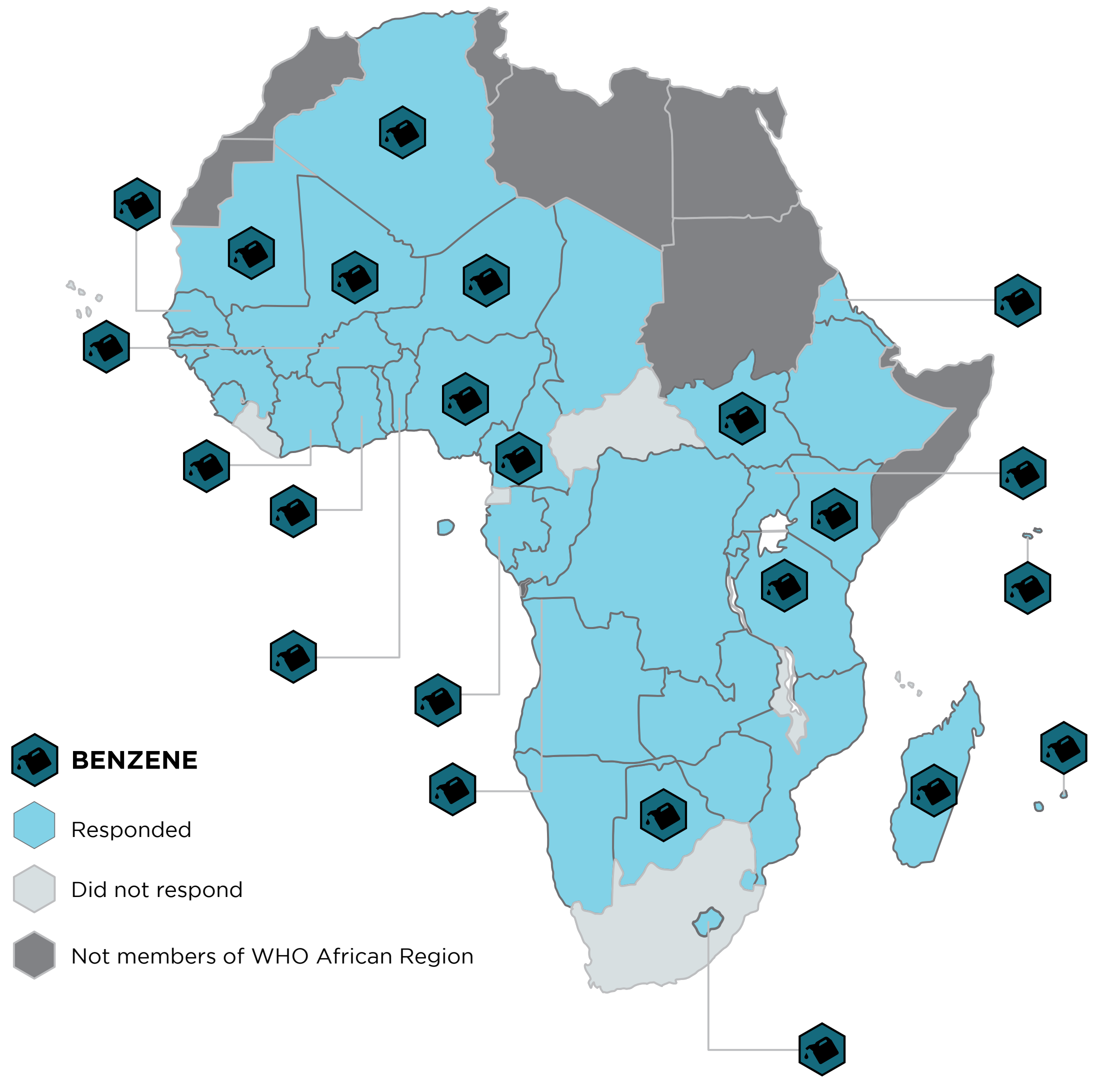


Figure 11: Countries reporting benzene as a public health issue in the WHO African Region



2.6 ASBESTOS

Public health impact

Asbestos is a group of minerals with thin microscopic fibres. Two types of asbestos fibres exist: serpentine and amphibole. The serpentine type has just one member, chrysotile (white asbestos), while the amphibole type has five members: amosite (brown), crocidolite (blue), anthophyllite, tremolite and actinolite. Amphibole asbestos fibres are needle-like in appearance and have been determined to be the most dangerous asbestos to which human beings can be exposed. Inhalation of these fibres is the main route of exposure to asbestos.

Significant exposure to any type of asbestos, including chrysotile, will increase the risk of lung cancer, mesothelioma and non-malignant lung and pleural disorders, including asbestosis, pleural plaques, pleural thickening and pleural effusions. Cigarette smoke is known to interact synergistically with asbestos to increase the risk of lung cancer.[116] Asbestos-related diseases have a long latency period and can take between 10 to 40 years to appear after exposure.

Clinical features and health impacts associated with asbestos

Clinical features

- Shortness of breath, persistent, dry cough, Loss of appetite with weight loss, finger clubbing, and chest tightness or pain. The effects of long-term exposure to asbestos typically do not manifest themselves for 10 to 40 years after initial exposure.

Health impacts

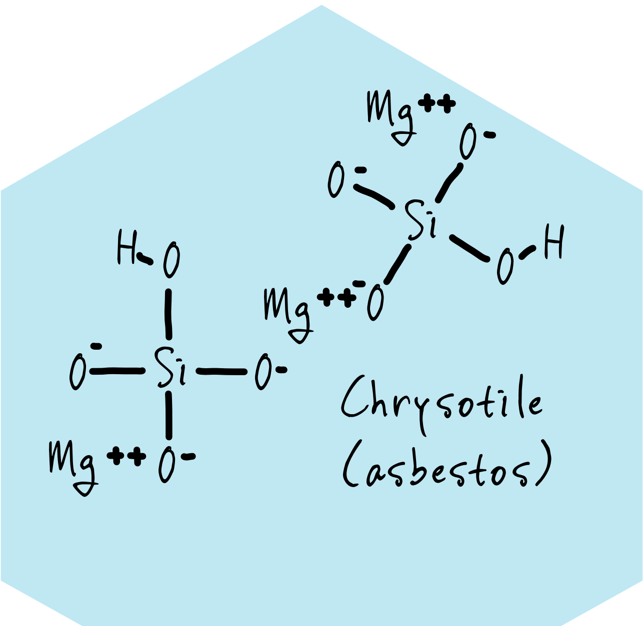
- Lung cancer, mesothelioma, asbestosis and diffuse pleural thickening.

Potential sources of exposure

Non-occupational exposure: Use of asbestos is banned in many industrialized countries, but its manufacture and use are common in many African countries, including Ghana, Nigeria and South Africa. In Nigeria asbestos is manufactured in many cities such as Kano, Lagos and Sapele and promoted as an essential building material. As a result, many houses in Nigeria today have asbestos components such as roofing sheets and water and sewerage drainage pipes. It is said that in some Nigerian communities, roofing a home with asbestos sheets is a symbol of affluence. In the Niger Delta Region of Nigeria, asbestos is the material of choice for roofing since it is known to resist corrosion from the acid rain that is prevalent in the region.[117] Similarly, in Ghana and South Africa, asbestos is frequently used in construction, in roofs, mouldings, floor tiles and electrical insulations. Left undisturbed, asbestos roofing sheets in themselves do not pose a hazard, but inhalation or ingestion of their deteriorated and released bulk material fibres creates serious public health hazards. In a survey conducted in the South African suburb of Soweto, 17% of asbestos roofs were in some state of disrepair,[118] and 62% of these homes lacked ceilings, which would serve as a barrier to indoor exposure to asbestos fibres.

Occupational activities can be a significant source of exposure to asbestos, such as asbestos mining, treatment of raw asbestos (milling), production of asbestos-containing products, transportation of asbestos, and repairs or demolition of buildings constructed with asbestos materials.[119,120] South Africa used to mine crocidolite, amosite and chrysotile, the three main commercial varieties of asbestos, and there have been reports of exposure to high levels of airborne asbestos fibres from abandoned and un-rehabilitated mines and randomly discarded asbestos fibre dumps, causing high rates of mesothelioma.[121]

Significant data gaps exist in regard to the extent to which the African population is exposed to asbestos and the extent of asbestos-related public health hazards. However, of the 40 Member States responding to the survey, only Côte d'Ivoire, Gabon, Mauritania, Seychelles and Togo identified asbestos as a chemical of public health concern.



2.7 PERSISTENT ORGANIC POLLUTANTS (POPS)

POPs are a group of toxic chemicals that adversely affect human health and the environment. Because they can be transported by wind and water, most POPs can and do affect people and wildlife that are located far from where substances are initially used and released. POPs persist for long periods in the environment and can accumulate in and pass from one species to another through the food chain.

To address the global concern about POPs, a number of treaties and non-binding legal agreements have been signed at international and regional levels, the most significant one of which is the Stockholm Convention. That convention initially targeted a group of 12 chemicals – the so-called dirty dozen – that were of primary public health and environmental concern. Of these, dioxins, furans and PCBs, which are industrial chemicals, are considered the most hazardous to humans,[122] while the other nine – aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex and toxaphene – which are used as pesticides, have varying degrees of toxicity. Details on dioxins, furans and PCBs are presented in the following section while pesticide POPs are discussed in Section 2.8 under "Pesticides".

2.7.1 DIOXINS, FURANS AND PCBS

Public health impact

Dioxins, furans and dioxin-like PCBs are the names of families of chemicals that have similar toxicity and shared chemical characteristics. The most toxic member of the dioxin group is 2,3,7,8 tetrachlorodibenzo-p-dioxin or TCDD. Toxicity of other dioxins and chemicals like furans and PCBs that act like dioxin is measured in relation to TCDD.

Exposure to dioxins, furans and PCBs has been associated with adverse health effects including birth defects, inability to maintain a pregnancy, decreased fertility, reduced sperm count, endometriosis, diabetes, learning disabilities, immune system suppression, lung problems, skin disorders, lowered testosterone levels and cancer. Dioxins and dioxin-like compounds are absorbed well after oral or dermal exposure and undergo extensive distribution throughout the body tissues, and particularly accumulate in the liver and adipose tissues.[123] Dioxins are eliminated slowly and are extremely persistent. For example, the half-life of TCDD in humans is considered to be approximately 7 to 12 years.[124]

Clinical features and health impacts associated with dioxins, furans and PCBs

Clinical features

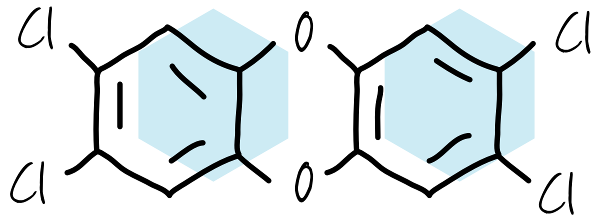
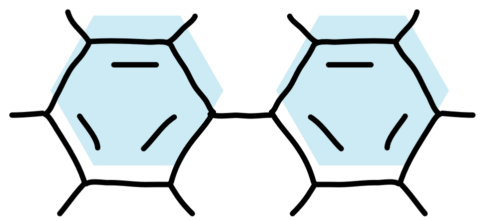
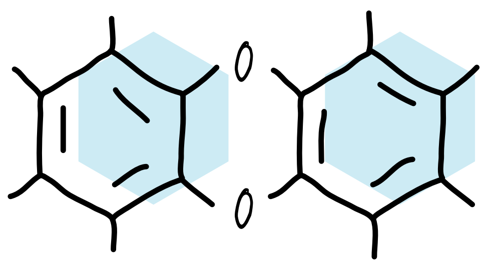
- Acute: Fatigue, cough and unusual skin sores. Burning sensation in the eyes nose and throat. Headache, dizziness, blurred vision, muscle and joint pain, impaired muscle coordination, asthenia, nausea, vomiting, emotional disorders, nervousness, irritability and intolerance to cold may all occur.
- Dioxins: Chloracne, an acne-like eruption of the skin, commonly occurs. PCBs: Dermal and ocular lesions, irregular menstrual cycles and lowered immune responses.
- Chronic: Immune system dysfunction, peripheral neuropathy and abnormalities of the liver, pancreas, and circulatory and respiratory systems.

Health impacts

- Acute: Exposure to high doses can cause skin lesions and impair liver function.
- Chronic: Long-term exposure to low doses of dioxins, furans and PCBs can result in shortening of the period of lactation in nursing mothers, immune system disorders, endocrine disruption, reproductive deficits, neurobehavioural impairment including learning disorders and attention deficits, diabetes, metabolic disorders and cancer.

The IARC classification of the carcinogenic risks of dioxins, furans and PCBs on humans is shown in Table 6.

Table 6: IARC carcinogenic classification of dioxins, furans and PCBs

TCDD		**Group 1**: Carcinogenic to humans
Polychlorinated biphenyls		**Group 2A:** Probably carcinogenic to humans
Polychlorinated dibenzo-para-dioxins (other than TCDD), polychlorinated dibenzofurans		**Group 3:** Carcinogenicity in humans is unclassified

Potential sources of exposure

Dioxins and furans are by-products of a range of chemical, manufacturing and combustion processes. These include production of certain pesticides, dyes and pigments, PVC plastic, and metal; paper pulp bleaching; incineration of municipal and hospital waste and sewage sludge; diesel-engine exhaust; accidental fires and explosions involving chlorine-containing materials; and wood combustion. In the past PCBs were manufactured as insulator fluids in heat-exchangers and transformers, as hydraulic fluids, and as additives for paints, oils, window caulking and floor tiles.

Incineration is believed to be a main method by which dioxins and furans are produced. In Africa, human exposure to dioxins, furans and PCBs is mainly from accidental or deliberate burning of waste (including domestic, electronic, health care and plastic waste) and bush burning. Human exposure to PCBs from old electrical equipment, mainly transformers and large capacitors, has been reported. For example, in a recent national survey in Malawi of 189 sites identified as contaminated with PCBs, nearly 83% had transformers manufactured between 1936 and 1989. [125] The waste oil from transformers was stored in drums stockpiled in open premises from where it leaked, contaminating the sites and causing human exposure to the chemicals.

Consumption of animal fats such as those from fatty fish, meat and milk products may also be a significant source of PCB exposure, as PCBs are known to bio-accumulate in fat-rich tissues.[126,127] PCB contamination in food has resulted in mass casualties in different parts of the world. For example, in 1968, over 14 000 people in Japan were poisoned after consuming chicken that had been fed PCB-contaminated rice bran oil.[128] The resulting illness, called Yoshō disease, had clinical features such as dermal and ocular lesions, irregular menstrual cycles and lowered immune responses.

The extent of human exposure to POPs in general and to dioxins, furans and PCBs in particular, has not been studied in detail in Africa. However, it is generally accepted that exposure to POPs is extensive, because these chemicals have been used and produced on the continent for a long time. Member States that identified these chemicals in their assessment reports are shown in Figure 12.

2.8 PESTICIDES

The term "pesticide" is a composite term that covers all chemicals used to kill or control pests. These include herbicides, insecticides, fungicides, nematocides and rodenticides (vertebrate poisons). According to the United States' Environmental Protection Agency (EPA), 60% of herbicides, 90% of fungicides and 30% of insecticides are known to be carcinogenic.[129]

In Africa, pesticides are used to increase the production of food, cotton fibre and tobacco and to control many vector-borne diseases such as malaria and typhus. However, many of these pesticides are extremely dangerous and exposure to them can result in adverse health problems.[130] According to a joint report from the Food and Agriculture Organization (FAO) and UNEP, approximately 30% of pesticides marketed in developing countries do not conform to international standards, contain active ingredients exceeding toxic thresholds, and do not exclude other toxic substances.[131]

Public health impact

A large proportion of pesticides still in use in Africa, particularly organochlorines and organophosphates, have been extensively evaluated toxicologically for a range of adverse effects and are known to induce a series of acute and chronic effects even at very low exposure levels.[132,133] A toxic effect common in them all is neurotoxicity.

According to WHO, an estimated 1–5 million cases of pesticide poisoning occur every year among agricultural workers and result in 20 000 fatalities, most of these in developing countries. In their self-assessment reports, a number of Member States including Burundi, Cameroon, Côte d'Ivoire, Kenya, Nigeria, Uganda and Zambia reported poisoning incidents from the use of hazardous pesticides. For example, pesticide-related poisoning events continue to occur countrywide in Kenya, with a total of 1 479 cases and 579 fatalities reported in 2012. In Uganda, pesticide poisoning incidents that occurred in 2012 in Wakiso and in 2013

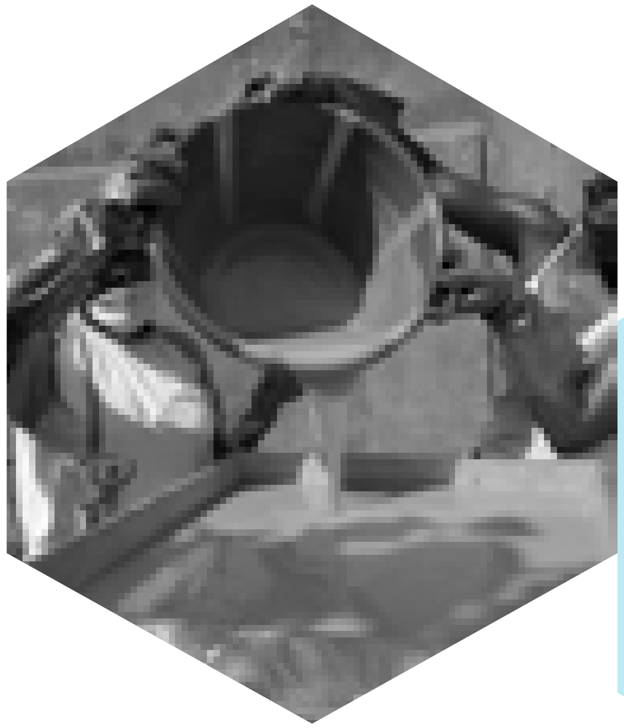
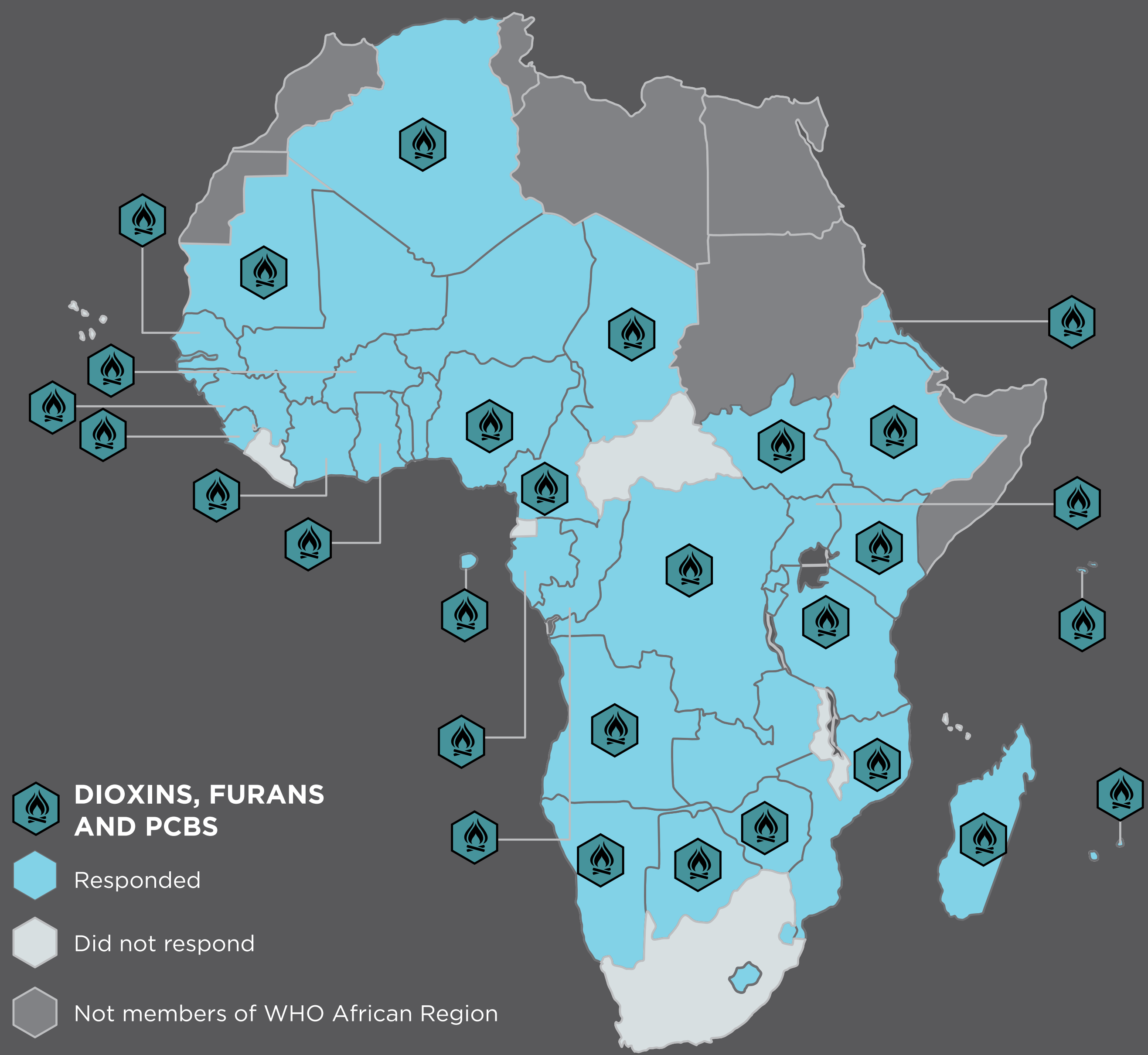


Figure 12: Countries reporting dioxins, furans and PCBs in the WHO African Region



in Pallisa caused a total of 87 fatalities. In Nigeria, pesticide poisoning in Kaduna State in 2012 resulted in an unconfirmed number hospitalized. Some of the most commonly used hazardous pesticides that are said to be currently in use in the WHO African Region include aldicarb, in WHO class Ia; carbofuran, in WHO class Ib; cyfluthrin, in WHO class Ib; dichlorvos, in WHO class Ib; and methomyl, in WHO class Ib where class Ia is extremely hazardous and U unlikely to present acute hazard (Tables 7 and 8).

Clinical features and health impacts associated with dioxins, furans and PCBs

Clinical features

- Acute: Diarrhoea, nausea, central nervous system excitation, irritation of the skin and upper respiratory tract, decreased pulse rate leading to dizziness and collapsing. Some pesticides cause convulsions, cognitive impairment, coma, liver and kidney impairment and lung fibrosis.
- Chronic: Impaired memory and concentration, disorientation, severe depression and confusion. Speech difficulties, delayed reaction times, nightmares, sleepwalking, drowsiness and insomnia.

Health impacts

- Neurotoxicity, human infertility and childhood cancer. Damage to nervous and immune systems.
- Pesticide POPs: Cardiovascular disease, obesity and diabetes have been linked to exposure to POP pesticides. Exposure to POP pesticides during pregnancy has been linked to developmental defects in offspring.

Table 7: Hazardous pesticides currently used in the WHO African Region

Pesticide	Function	Toxicity (per WHO)	Reporting countries
Aldicarb	Insecticide, nematicide	Extremely hazardous	Burundi
Carbofuran	Insecticide, nematicide	Highly hazardous	Guinea, Togo
Cyfluthrin	Insecticide, parasiticide	Highly hazardous	Guinea, Mali
Dichlorvos	Insecticide, parasiticide	Highly hazardous	Burundi, Congo, Nigeria
Methomyl	Insecticide	Highly hazardous	Guinea Bissau

Table 8: WHO recommended classification of pesticides by hazard, 2009

WHO pesticide toxicity classification		LD50 for the rat (mg/kg body weight)	
WHO Hazard classification	**WHO class**	**Oral LD50**	**Oral LD50**
Extremely hazardous	Ia	5 or below	50 or below
Moderately hazardous	II	50 - 2 000	200 – 2 000
Highly hazardous	Ib	5 - 50	50 – 200
Slightly hazardous	III	Over 2 000	Over 2 000
Unlikely to present acute hazard	U	5 000 or higher	5 000 or higher

Potential sources of exposure

Pesticides are used for pest control in different environments such as the home and various forms of agriculture. In Africa, however, it is their unregulated use in agriculture that is causing high-dose exposure and widespread release into the environment.

Farming: Scientific literature indicates that pesticide use is greater in cotton farming than in any other single agricultural commodity, and that regulating pesticide use in cotton production deserves special attention. Hazardous pesticides that are widely used in large volumes in cotton production include aldicarb (WHO class Ia), parathion (WHO class Ia), methamidophos (WHO class Ib), alphacypermethrin (WHO class II), deltamethrin (WHO class II) and endosulfan (WHO class II). These pesticides are reportedly widely used in cotton growing areas of several West African countries including Benin, Burkina Faso, Cameroon, Mali and Senegal and to have caused poisoning and fatalities.[134] Of these pesticides, the most dangerous are those containing endosulfan, which accounted for 69% of the recorded cases of poisoning.[135]

Typically, human exposure to pesticides used in agriculture is highest among farm workers, pesticide appliers and those who live adjacent to heavily treated agricultural land.[17] In addition to being frequently exposed to a wide array of pesticides, farm workers and pesticide appliers are likely to be exposed to high doses by multiple routes. Misuse of highly toxic pesticides, a lack of attention to safety precautions, poor spraying techniques and inadequate personal protection during pesticide use are some of the main reasons for the high incidence of pesticide intoxication observed in Africa.[136] Surveys indicate that only a small percentage of African farmers consistently use appropriate personal protective equipment (PPE) while spraying pesticides.[17,137,138] Cost is frequently cited as a significant obstacle to the appropriate use of PPE. Other factors are the hot and humid climatic conditions that make wearing PPE uncomfortable, failure by employers to provide the necessary equipment and a belief that PPE is either not needed or is ineffective.[17,139] Ghana, for example, reported that application of various hazardous pesticides such as paraquat (WHO class II) and aluminum phosphide (a toxic fumigant) by farm workers without adequate protective clothing was a key cause of pesticide poisoning in the country.

Food: Pesticide exposure also occurs through ingestion of treated crops. In Uganda, consumption of pesticide contaminated amaranth (dodo) has been reported as a major source of pesticide poisoning in the country. The re-use of pesticide containers for storing food and drink was highlighted by several Member States as a source of poisoning. For example, Ghana reported pesticide poisoning of children in Chichonga village attributed to container re-use as did Gabon.[140] In a study in the cotton zones of Senegal and Benin, 75% of recorded poisoning cases were attributed to food and drink contamination from the re-use of pesticide containers rather than exposure to pesticides during spraying.[141]

Obsolete pesticides, when not managed properly, present a serious public health and environmental concern by contaminating the air, soil, water and food sources. According to FAO, the key reasons for the accumulation of obsolete pesticides in Africa are:

(a) increased use of pesticides in agriculture to combat outbreaks of locusts, mosquitoes, quelea birds, tsetse flies and pests
(b) product bans
(c) inadequate storage and poor stock management of pesticides
(d) pesticide donations or purchase in excess of requirements
(e) lack of coordination regarding pesticide distribution among donor agencies
(f) commercial interests of the private sector

Lack of designated disposal sites is a major factor forcing farmers to store obsolete pesticides in open spaces or on farms, which eventually results in pesticides leaching into the soil during rain. It is estimated that there are about 50 000 tonnes of obsolete pesticides in Africa awaiting safe disposal.[142] Table 9 shows obsolete pesticide stocks in some Member States as of 2008.[143]

Indiscriminate use of pesticides represents one of the main environmental and public health problems in Africa, contributing to soil contamination, water pollution, destruction of useful organisms and development of pesticide resistance in pests, and consequently leading to harmful effects on the health of both farmers and food consumers.[132] The typical pesticides detected in soil, water and crops include organochlorines such as DDT, endosulfan and lindane.[144,145] For example, hazardous pesticides including DDT and its breakdown products endosulfan I and II, endosulfan sulfate and profenofos were detected in 77% of the soil samples collected

Table 9: Obsolete pesticide stocks in selected African countries

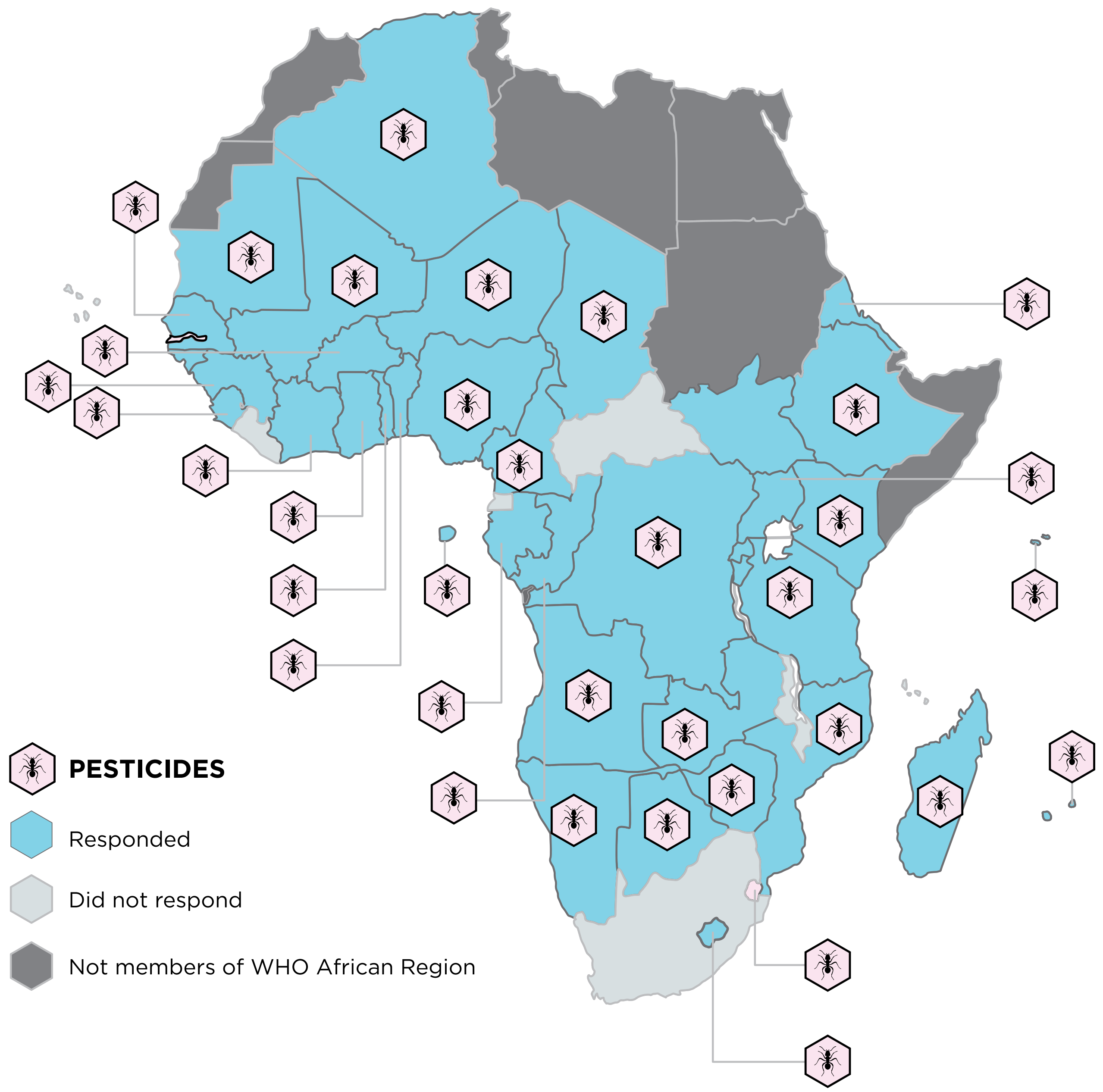
Country	Obsolete pesticide stocks (kg)
Botswana	100 000
Eritrea	500 000
Ethiopia	300 000
Lesotho	200 000
Malawi	311 000
South Africa	700 000
Swaziland	90 000
Tanzania	1 500 000

from four cotton production sites in Mali.[146] Similarly, residues from six banned or restricted chemical pesticides – DDT, endosulfan, lindane, aldrin, dieldrin and endrin – were reported in food samples in Ghana. These chemicals were considered by a recent personal biomonitoring study conducted in Ghana to be responsible for the elevated levels of organochlorine pesticide residues (including DDT and its metabolite DDE) detected in breast milk and blood samples from farming communities.[145,147]

Humans are substantially exposed to DDT and DDE through indoor spraying. Such exposure may result in a range of health effects, including reduced fertility, genital birth defects, breast cancer, diabetes and damage to the developing foetus's brain. DDE is known to also block male hormone activity.

DDT is one of the 12 original POPs banned under the Stockholm Convention, but its use in the control of malaria and other vector-borne diseases has been granted a "health-related exemption" by the Parties to the POPs treaty until cost-effective substitutes for malaria control are found since cessation of DDT use caused catastrophic epidemics of malaria in several parts of the world. For example, when Madagascar stopped using DDT in the 1980s, it immediately suffered epidemics of malaria that resulted in the death of more than 100 000 people.[148]

Figure 13: Countries reporting pesticides in the WHO African Region



3 CHEMICALS MANAGEMENT SYSTEMS IN THE AFRICAN REGION

3.1 REGIONAL CAPACITY FOR PREVENTION, DETECTION AND MANAGEMENT OF CHEMICAL RISKS

3.1.1 LEGISLATION AND POLICY

Legislation is a prerequisite to prevent, detect and manage chemical risks in a timely manner. Such legislation needs to be developed and implemented through a multisectoral approach that engages, among others, the health sector. Effective chemicals legislation requires monitoring as well as establishment and operation of proper chemical management and disposal systems.

In order to assess the regional capacity for prevention, detection and management of chemical risks, Member States were asked to state if they had legislation, policies or regulations governing the use and management of chemicals, and if they had such tools, whether they encompassed all chemicals. Of the 40 Member States responding to the survey, 15 (38%) indicated that they had comprehensive legislation and integrated policies to govern most chemicals and chemical products; 20 (50%) indicated that they had legislation, laws and policies but these were sector based and for chemicals specific to only the sector concerned; and five (12%) indicated that they had not yet developed legislation or policies on chemicals (Figure 13).

Recognizing the risks chemicals pose to public health and the environment, many Member States have embarked on the development of national legislation and policies for the safe use and management of chemicals. However, legislation that exists typically is not completely enforced because implementation mechanisms are not in place. Moreover, because much existing legislation is sector based and does not cover all chemicals, many toxic chemicals are not regulated by legal provisions, including heavy metals in consumer products such as lead in paints, mercury in soaps and skin-lightening creams, and POPs such as PCBs from old transformers and dioxin emissions from waste burning.

In Africa, the regulation of chemicals is pursued primarily through global mechanisms governing chemicals termed multilateral environmental agreements (MEAs). The most important chemical-related conventions and MEAs that have been adopted by Member States are described below.

(a) The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal was adopted in 1989 and entered into force in 1992. It provides a legal framework for controlling transboundary movement of hazardous waste and its disposal. This convention has 181 parties, of which 50 are African countries.

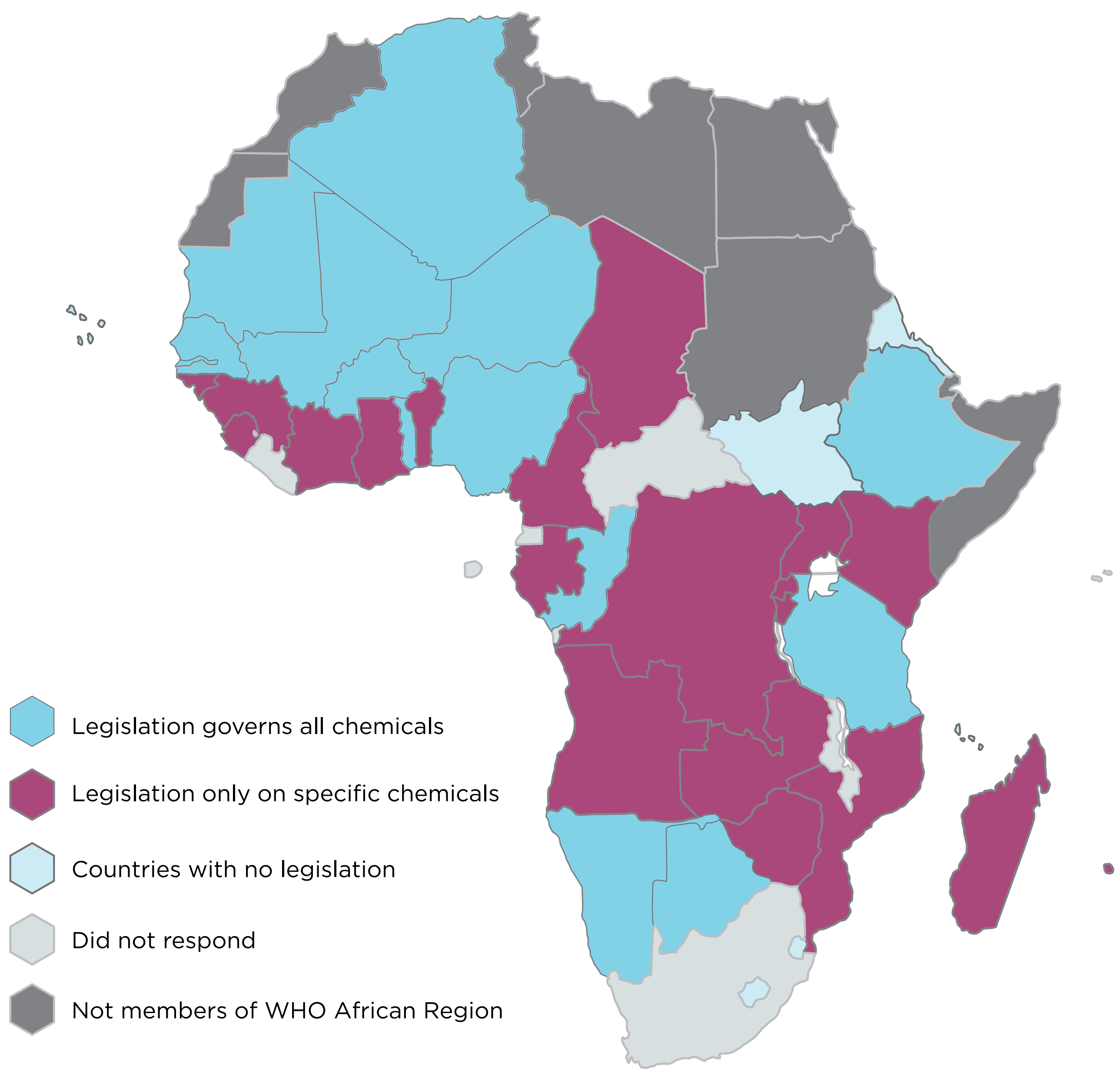
(b) The Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa was adopted in 1991 and entered into force in 1998. This convention specifically controls the movement of hazardous waste within Africa. It has 24 parties and 30 signatories. Only states that are members of the African Union can become parties to the Bamako Convention. The Libreville Declaration of August 2008 expressed concern about the failure to sufficiently or effectively implement the Bamako Convention.[149]

(c) The Stockholm Convention on Persistent Organic Pollutants, which was signed in 2001 and entered into force in 2004, aims at protecting human health and the environment by prohibiting the use, production, import and export of 12 persistent organic pollutants (POPs). These include DDT, dioxins and PCBs. The Stockholm Convention has 179 parties of which 51 are African countries. The number of chemicals covered by this convention has increased.

(d) The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade was adopted in 1998 and entered into force in 2004. It seeks to limit trade in certain hazardous chemicals and pesticide formulations in order to protect human health and the environment. This convention has 154 parties, of which 47 are African countries.

These agreements require country-level commitment that can be fostered through a cooperative regional approach. However, their implementation is generally unsatisfactory because many Member States have not yet adopted an integrated approach to chemicals management. It is argued that existing legal frameworks are not sufficiently comprehensive to deal with the entire process of chemical importation, registration, authorization, storage, use and disposal. Moreover, loopholes have been blamed for reported illegal transboundary movement of chemicals into and within the Region. For example, it is reported that African countries are so exposed to illegal trafficking of waste defined as hazardous by the Basel Convention that many collectors and exporters of ferrous materials incorporate prohibited chemicals such as PCBs in the circuit materials they send to Africa. There are also reports of illegal transboundary movement of chemicals within the Region. For example, in their national chemical profile, Malawi attributed the presence and use of seven POPs banned by the country to smuggling through its borders with Mozambique, Zambia and Tanzania. Mercury destined for the ASGM sector in Africa is also said to be smuggled into or within the Region.

Figure 14: Legislation on chemicals in the WHO African Region



3.1.2 COORDINATION, COLLABORATION AND PARTNERSHIP MECHANISMS

Implementation of international conventions related to chemicals requires strong institutional mechanisms that allow effective intersectoral coordination and collaboration. In the absence of such mechanisms the formulation of a strategic approach and the translation of treaties on chemical management into action at the national level will not be effective. Often, the responsibility for chemical management in African countries is split among several sectors, and in most cases no system exists to coordinate or foster collaboration among those sectors.

The self-assessment questionnaire specifically asked Member States if they had any structure or body to coordinate or foster collaboration between the different sectors involved in chemical management. Member States reported on their existing mechanisms as follows: 11 (27%) stated that they had multisectoral committees or commissions set up following IHR (2005) guidelines to deal with chemical management, eight (20%) indicated that their ministry of environment was the designated body to oversee issues on chemical management, 15 (38%) indicated that they had committees in different sectors or institutions but no effective coordination occurred among them, and four (10%) indicated that they did not have any coordination mechanism or structure. Algeria and Niger indicated that they did not know if such a mechanism or structure existed in their countries (figure 15).

3.1.3 SURVEILLANCE CAPACITY

The international community, through the work of the World Health Assembly, has recognized the need to strengthen surveillance of chemical incidents. There are three main reasons for this:[150] first, the continuing rapid growth and globalization of the chemical industry means that chemical incidents will continue to pose a problem, second, chemical incidents may have an impact beyond their original location in some cases crossing national borders, and third, there is concern regarding the deliberate use of chemicals for terrorist purposes, engendered by events such as the use of sarin in the Tokyo underground system.[151]

Chemical incident surveillance systems have a critical role in planning and preparedness for chemical incidents. Properly collected and audited surveillance data can be used to inform involved agencies about public health decisions and help ensure that lessons are learnt from chemical incidents when they occur. Chemical incidents constitute priority events in terms of the WHO African 2010 Integrated Disease Surveillance and Response (IDSR) technical guidelines and, therefore, should be reported to the appropriate level immediately after they occur. Chemical incident surveillance data can also be used to design training programmes for public health professionals to prepare for chemical incidents and to give direction to regional publications and guidance on hazardous chemicals. Data from surveillance systems can also be used to help develop a regional strategy on chemical decontamination and on the use of personal protective equipment by quantifying the frequency and severity of chemical incidents.

In Africa, environmental and public health surveillance systems for chemical incidents are in general considered not to exist, and if they do, are often weak. This is reflected in the findings of this survey. The self-assessment questionnaire asked Member States if they had surveillance capacity at the country level to detect chemical events. Of the responding Member States, 13 (32%) indicated that they had such capacity or alert systems, 24 (60%) said that they did not, and three (8%) that they did not know if that capacity existed in their country because they had not yet undertaken an evaluation of the core capacity for detection and surveillance of chemical events in the context of the IHR (2005) guidelines (Figure 16). Among the countries that had surveillance capacity, Ghana, Kenya, Lesotho, Namibia and Tanzania reported that they had operational IHR/IDSR guidelines or tools for surveillance and alert systems.

Figure 15: Mechanisms for coordination, collaboration and partnership for chemical management in WHO African countries

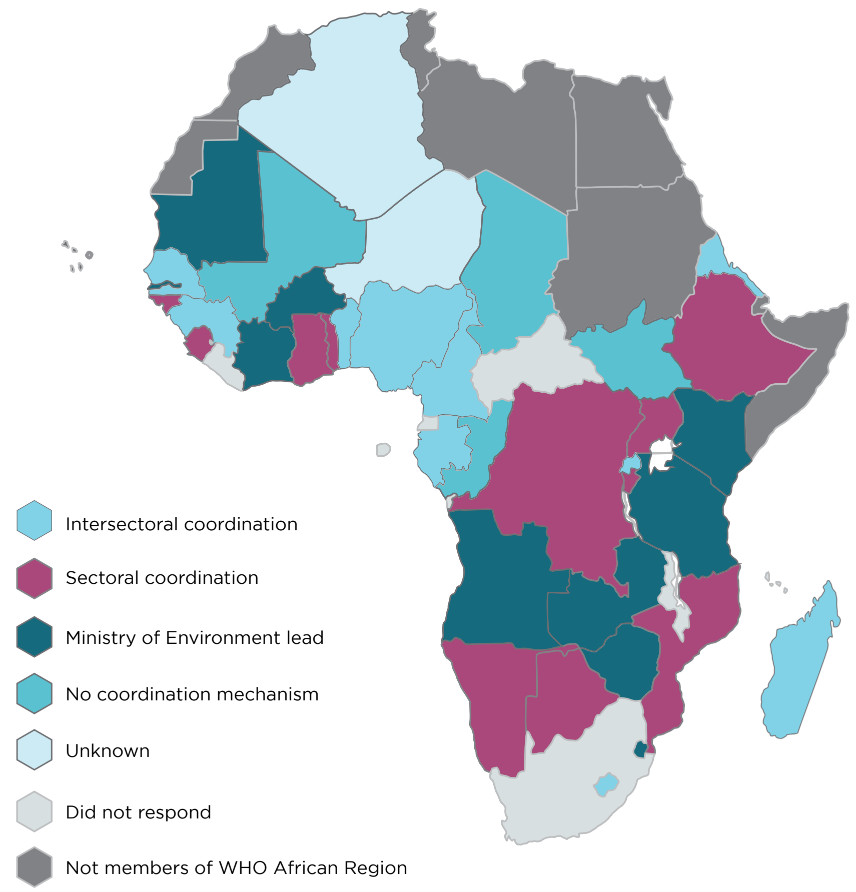
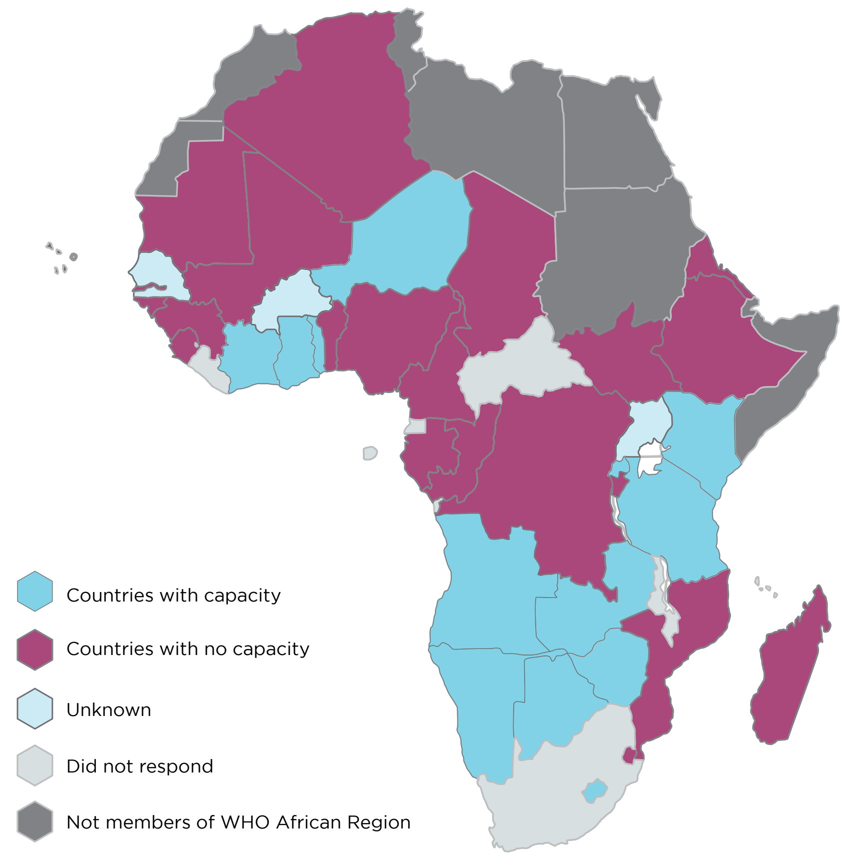


Figure 16: Surveillance capacity for chemical incidents in the WHO African Region



3.1.4 LABORATORY CAPACITY

Laboratory services play a major role in all the key processes of IHR, including detection, assessment, response, notification and monitoring of events. For a long time, laboratory services have not been considered a priority in most resource-limited healthcare systems in Africa, and so in general laboratory infrastructure is poor, human resource capacity is low, and technologies inappropriate.[152]

In this study, to assess laboratory diagnostic capacity, Member States were asked if they had developed the required laboratory capacity to detect and analyse chemicals in soil, water and food. Of the 40 Member States responding, 20 (50%) indicated that they had capacity, 10 (25%) said that their capacity was limited to monitoring chemicals in water and food but not in soil, and 10 (25%) said that they did not have the required capacity (Figure 17).

Figure 17: Laboratory capacity for chemical detection in the WHO African Region

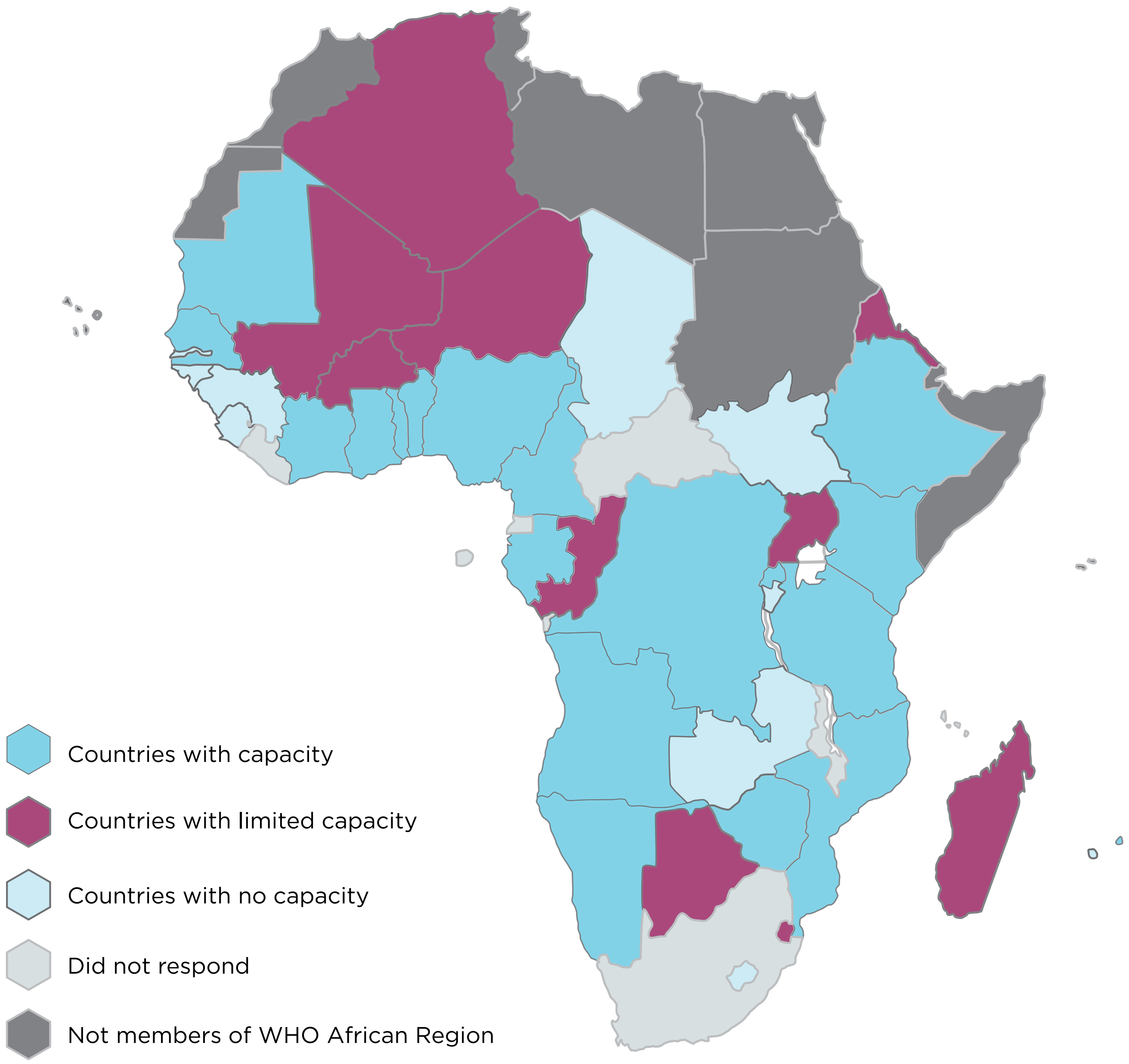


Table 10: Availability of laboratory equipment in the WHO African Region

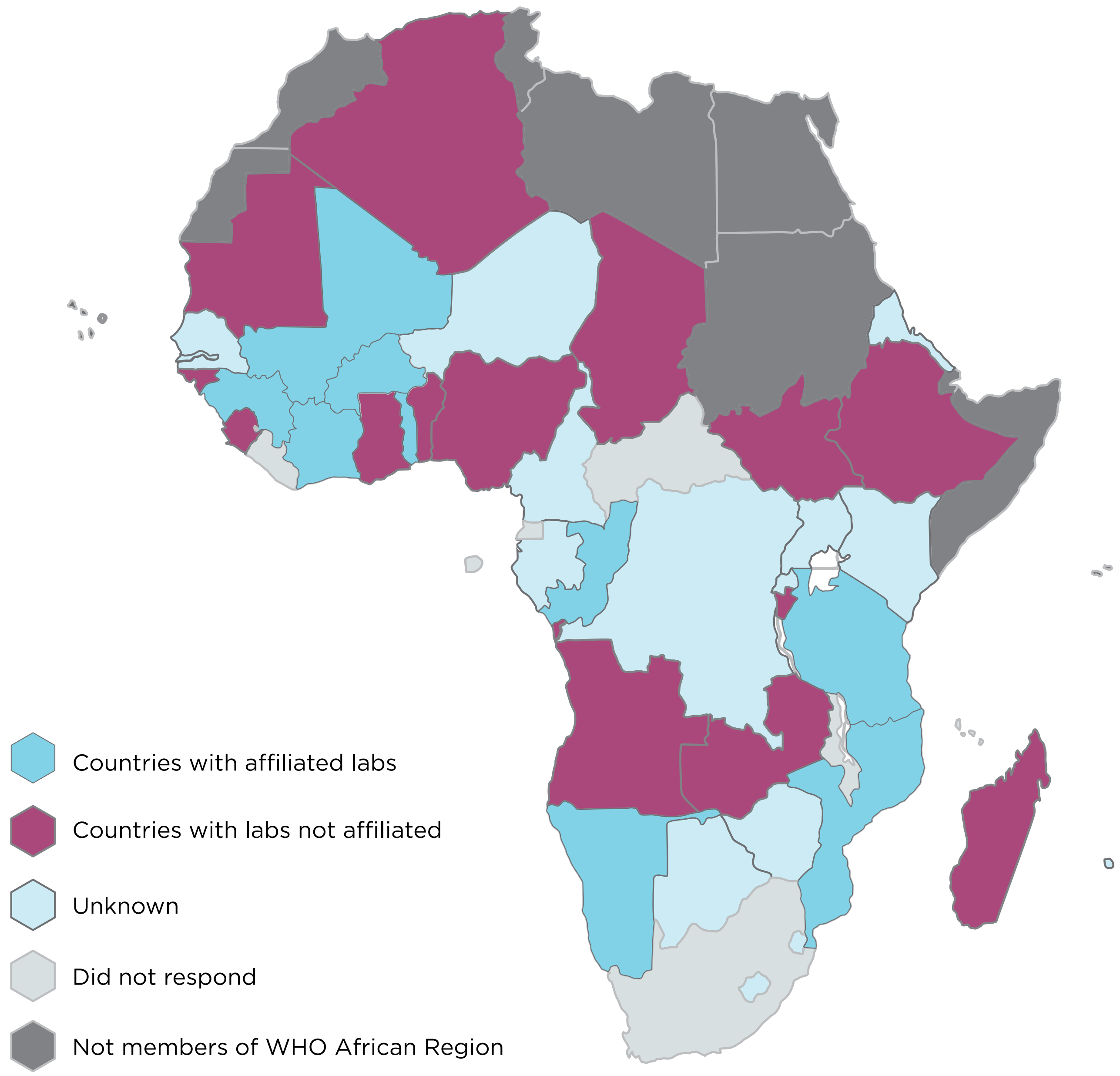
Equipment	Countries with the equipment	No. of countries with the equipment
Atomic absorption spectrophotometer	Algeria, Botswana, Burkina Faso, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ghana, Guinea, Kenya, Mali, Mauritius, Nigeria, Sao Tome and Principe, Seychelles, Swaziland, Togo, Uganda, United Republic of Tanzania and Zambia	19
Flame photometer	Algeria, Botswana, Burkina Faso, Eritrea, Ghana, Guinea, Guinea-Bissau, Kenya, Mali, Mauritius, Mozambique, Nigeria, Togo, Uganda, United Republic of Tanzania and Zambia	16
Gas chromatograph	Algeria, Botswana, Burkina Faso, Ghana, Guinea, Guinea-Bissau, Kenya, Mali, Mauritius, Mozambique, Nigeria, Rwanda, Seychelles, Togo, Uganda, United Republic of Tanzania and Zambia	17
High performance liquid chromatograph	Algeria, Burkina Faso, Democratic Republic of the Congo, Ghana, Guinea, Guinea-Bissau, Kenya, Mali, Mauritius, Mozambique, Nigeria, Rwanda, Seychelles, Uganda, United Republic of Tanzania and Zambia	16
Inductively coupled plasma-mass spectrometer	Algeria, Burkina Faso, Ghana, Kenya, Mauritius, Togo, Uganda and United Republic of Tanzania	8
Infrared spectrophotometer	Botswana, Burkina Faso, Kenya, Mali, Nigeria, United Republic of Tanzania and Zambia	7
X-Ray diffractometer	Burkina Faso and Kenya	2

Member States were also asked if they had set up national reference laboratories to confirm chemical events. Of the 40 Member States responding to the survey, 21 (53%) indicated that they had reference laboratories for chemical event monitoring, detection and confirmation, 18 (45%) indicated that they did not have reference laboratories, and one (2%) said that they did not know if their country had a reference laboratory (Figure 18). The capacity of the national reference laboratories in the African Region has also been assessed for availability of basic equipment to detect and analyse some of the chemicals of major public health concern, and the findings are provided in Table 10.

Figure 18: Presence of national reference laboratories in the WHO African Region

Where resources are scarce and inequitably distributed, establishment of chemical laboratory networks at national, regional or international level could help to ensure the timely exchange of information and adequate support in laboratory services. Member States were asked if they had established linkages or partnerships with external laboratories for detection, or confirmatory testing of chemical events. Of the 40 Member States responding, only 10 (25%) indicated that their laboratories were affiliated with other regional or international laboratories. Among those were Guinea, which mentioned the Centre Hospitalier affilié Universitaire de Quebec in Canada; Togo, which has links with the Senegal Pasteur Laboratory and a laboratory in Accra, Ghana; Burkina Faso, which collaborates with the Laboratory of Montpellier in France; Côte d'Ivoire, which works with the Wessling Laboratories in France; Mozambique, which collaborates with laboratories in South Africa; and Mali, which listed multiple partner laboratories such as the African Medicine Quality Control Laboratories Network, the United States Pharmacopeia Drug Quality Program and the Réseau Africain de laboratoires d'hygiène alimentaire (figure 19).

Figure 19: Member States with affiliated laboratories

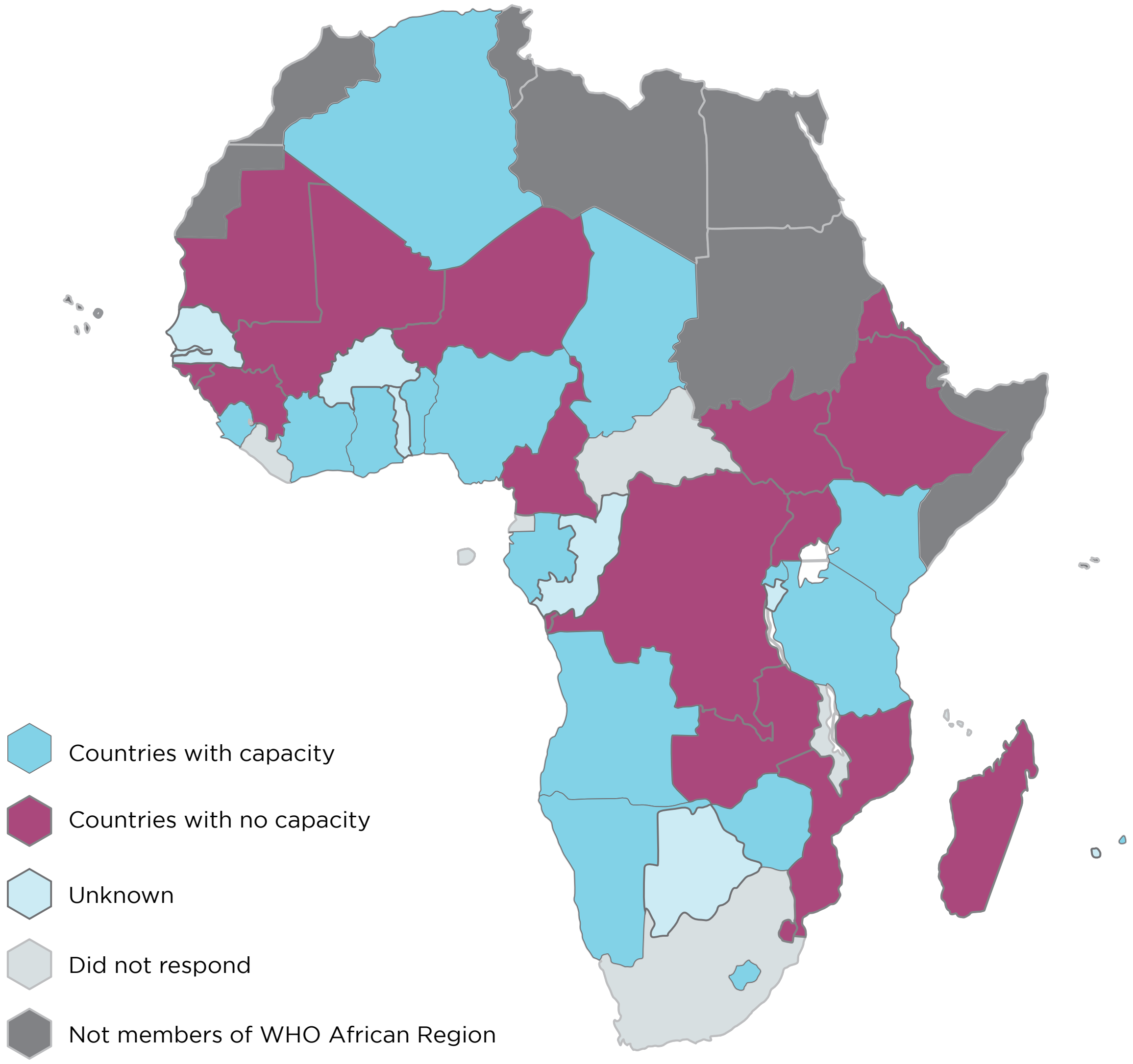


3.1.5 HUMAN RESOURCE CAPACITY

The capacity to develop and implement an effective management system for chemicals depends on, among others things, availability of highly trained and motivated personnel who are not only technically competent but also possess strong leadership and managerial skills.

The self-assessment questionnaire asked Member States if they had the required human resource capacity for identifying chemical events. Of the 40 Member States responding to the survey, 21 (52%) indicated that they had limited capacity but underlined the need for capacity building, 14 (35%) indicated that they did not have such capacity, and five (13%) said that they did not know if such capacity existed in their country because they had not undertaken a national assessment of human resources capacity (Figure 20).

Figure 20: Human resource capacity for chemical management in the WHO African Region



3.1.6 CAPACITY OF POISONS CENTRES

Poisons centres in developing countries are set up to reduce mortality and morbidity from poisoning. The services offered range from provision of poisons information to actual clinical treatment, mostly of acute cases. Recently, poisons centres have expanded their role to be more actively engaged in community health studies, toxicovigilance and treatment of chronic poisoning.

To determine the number and assess the capacity of existing poisons centres and toxicology units in the African Region, Member States were asked to indicate if they had such facilities and also to state if the facilities had adequate resources. According to the data collected, 10 (25%) of the 40 Member States responding had poisons centres or toxicology units (Figure 21). Member States that had poisons centres or toxicology units were Algeria, Angola, Côte d'Ivoire, Gambia, Ghana, Kenya, Madagascar, Nigeria, Senegal and Zimbabwe. Ghana, Kenya, Nigeria and Zimbabwe stated that their poisons centres were not used much because they had a critical shortage of resources. Ghana indicated that it had a poisons centre that was administered under the Occupational and Environmental Health Unit but that it was poor in human and material resources. Kenya reported that its poisons centre at Kenyatta National Hospital did not have adequate resources. The centre receives reports on and responds to cases of poisoning, but its emergency preparedness capacity is not adequate to deal with chemical incidents. The centre has two toll-free lines that members of the public could use to report cases of poisoning, but it has not developed systems to create public awareness of its services in the country.

Among the countries that reported having adequate resources for their poison centres, Algeria had a poisons and a call centre with a 24-hour telephone answering service to respond to any type of poisoning incident. Madagascar indicated that it had a Drug Information and Toxicology Unit (UNIMINTOX) with a toll-free number to provide information and advice about all forms of poisoning, and Senegal had one poisons centre under the ministry of health responsible for management of poisoning cases, and one toxicology service unit at the Cheikh Anta Diop University in Dakar. Although they do not have poisons centres or toxicology units, Burkina Faso and Tanzania indicated in their reports that they had toxicology laboratories that host chemical databases and provide information to external poisons centres.

Figure 21: Presence of poisons centres or toxicology units in the WHO African Region

Countries with poisons centres /toxicology units

Countries with no poisons centres /toxicology units

Did not respond

Not members of WHO African Region

3.2 MANAGEMENT OF CHEMICAL WASTE

Waste production in Africa exceeds available capacity for its collection and disposal.[153] According to the United Nations Centre for Human Settlements (UNCHS), only one-third of the solid waste generated in urban areas across Africa is collected, and of that only 2% is recovered and recycled.[154] Burning solid waste in open air is common in Africa. Industrial activities are primarily responsible for the increase in quantity, complexity and toxicity of chemical waste. Thousands of tonnes of industrial waste, containing hazardous chemicals, are improperly discharged or emitted. Industrial waste in liquid form is usually discharged into sewerage systems or rivers as effluent, while solid waste is either dumped in landfills or pits within workplace premises.

From the analysis of information from the self-assessment reports from the Member States, it is evident that chemical waste management has become a major public health issue in the African Region. Of the 40 Member States participating in the survey, 22 (55%) identified various forms of chemical waste as being of concern, such as electronic and healthcare waste, and highlighted the fact that mismanagement of such waste had resulted in extensive environmental contamination and public health problems. It was also reported that the main factor in the mismanagement of waste was the lack of integrated waste management policies and strategies, and that existing legislation dealt with only general management of chemical waste without providing the means for handling and disposing of specific chemical waste.

3.2.1 RECYCLING AND DISPOSAL FACILITIES

The choice of treatment and disposal strategies for any country critically depends on the full awareness of the volume and understanding of the type of waste being produced. Such information is essential for estimating the capacity of storage containers, on-site and off-site waste disposal, treatment facilities, transportation systems etc. A proper inventory of waste generated is rarely available in African countries, and quite often waste management programmes are forced to rely on waste volumes estimated using generation factors.[155,156] In view of the complexity of the issues and risks associated with waste, an inventory of the number and distribution of waste recycling and disposal facilities is essential to guide efforts to improve their safety and to reduce the threat to public health.

Africa lacks appropriate, cost-effective and economically viable technology for chemical waste recycling and disposal. Analysis of the data from the 40 Member States responding to the survey shows that only 14 (35%) had facilities of some kind for recycling or disposing of chemical waste such as landfills, transfer stations and waste incinerators, and these were mainly for lead-acid batteries, waste motor oil and plastics (Figure 22). Additionally, some Member States reported that they were using the opportunities offered by the Basel Convention on the control of transboundary movement of waste to transfer waste to approved centres mainly in South Africa and Europe.

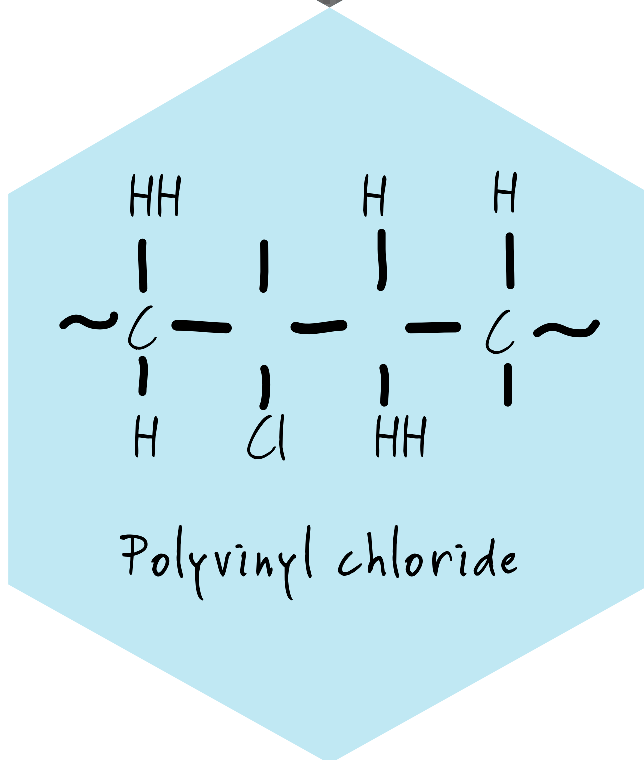
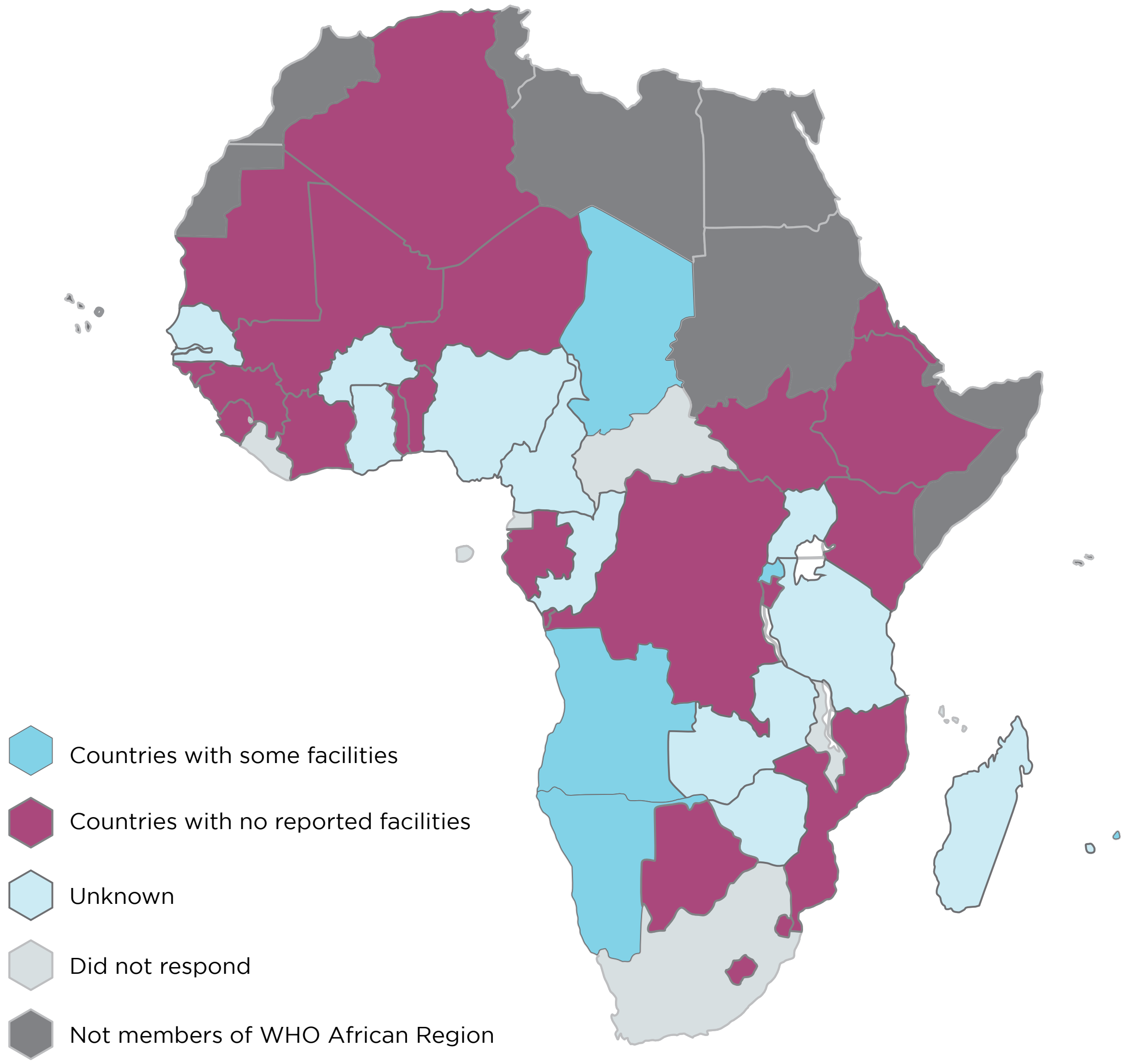


Figure 22: Capacity for chemical recycling and disposal in the WHO African Region



3.2.2 HAZARDOUS CHEMICAL WASTE

In generic terms, waste can be defined as "an avoidable by-product of most human activity". In Africa, waste generation has been rising over the years with population growth, industrial development and modernized consumption patterns. Moreover, industrial diversification and expansion of healthcare facilities and services have added substantial quantities of industrial and biomedical waste into the waste stream with potentially severe environmental and public health consequences. It has recently been estimated that unsanitary disposal of waste has placed 50% or more of the current population of Africa at occupational, environmental or public health risk.[157]

Although many types of chemical waste pose health risks, from the public health perspective the most hazardous include electronic, medical, petrochemical and plastic waste.

Electronic waste

Electronic equipment contains a number of toxic materials including heavy metals such as cadmium, lead and mercury. Indiscriminate dumping and burning of waste containing a range of electronics such as televisions, microwaves, transformers, refrigerators and batteries is common in many parts of Africa and upon burning, such waste releases toxic pollutants including POPs and heavy metals. In Africa, this waste is always disposed of in general waste sites without any particular treatment to render it safe for the environment and people. As a result, there is growing concern that electronic waste is contaminating the environment with tragic effects on the lives of many people. For example, battery waste is commonly disposed of as general waste in many parts of Africa, moreover, in Madagascar and other countries, many families practice informal household waste incineration.[14]

Importation of electronic products almost at the end of their useful life, as well as obsolete products, is on the rise in Africa. For example, according to a 2013 report, Ghana imports around 215 000 tonnes of second-hand consumer electronics and also generates 129 000 tonnes of electronic waste every year.[113] The country has an electronic waste processing plant in Agbogbloshie in Accra, which is the second largest such facility in West Africa. In its 2013 report on the "top ten toxic threats" the Blacksmith Institute ranked Agbogbloshie as the third most toxic place on the planet.[113] Waste processing emits a range of toxic chemicals into the air, soil and water, including heavy metals, phthalates and chlorinated dioxins. Soil samples taken from areas of Agbogbloshie had lead levels as high as 18 125 ppm.[158] The EPA standard for lead in soil is 400 ppm. Heavy metals released in the burning process readily migrate into homes, food markets and other public areas exposing an estimated 40 000 people to chemical risks.[159] Côte d'Ivoire, Gabon, Madagascar, Rwanda and Tanzania also indicated in their self-assessment reports that electronic waste is increasingly becoming a major public health issue.

As noted in the UNEP-Global Environment Outlook (GEO) 4, Africa continues to be at risk from hazardous electronic waste dumping because monitoring capability and institutional mechanisms for managing such waste are inadequate.[32] The influx of low quality computers, cell phones and other electronic equipment makes it urgent to implement stricter import regulations and to develop mechanisms to collect non-functioning items.

Medical waste

Medical waste may often contain hazardous chemicals including heavy metals and plastics containing polyvinyl chloride (PVC). Such waste must be disposed of in ways that minimize the risk to public health and the environment. However, in Africa, medical waste is usually treated as if it were non-hazardous and is commonly disposed of with general waste or burned in open air. Incinerators are also often used to dispose of medical waste, but these are probably responsible for the release of hazardous gases and compounds into the environment. Incineration of medical waste containing hazardous chemicals at temperatures lower than 800 °C results in the release of toxic gases including dioxins and furans and various other airborne pollutants. Incineration of medical waste with a high content of metal such as lead, mercury and cadmium releases the metal into the environment. In their self-assessment reports, Algeria, Burundi, Côte d'Ivoire, Kenya, Lesotho, Madagascar, Mauritius, Nigeria and Togo highlighted the concern that their populations continued to be exposed to hazardous chemicals from open burning and incineration of chemical waste, including medical waste.

In Africa, unsanitary disposal of waste has put millions of lives at risk because dump sites are often visited by people scavenging for useful or sellable items. The lack of sanitary landfills has also increased the use of incinerators. Gambia, Ghana, Lesotho, Nigeria, Senegal and Tanzania have no sanitary landfills, while Kenya and Zambia have only crude dump sites. It is estimated that Africa has more than 1000 incinerators, but many of these are said to be inoperative or operating below standard.[160]

Petrochemical waste

Used motor and industrial lubrication oils are mostly treated as non-hazardous waste in Africa although they contain toxic chemicals such as PAHs and heavy metals. Currently, many African countries lack the capacity to build treatment or recycling facilities for these oils, so such waste is either disposed of indiscriminately or burnt in furnaces. Used oil that is not managed properly is likely to get into storm drains or groundwater, thereby affecting human health and the ecosystem. The main sources of waste oil and oil-contaminated solid waste are garages, petrol stations and auto repair shops. In Africa, waste generated from these facilities is frequently poorly managed and contaminates the soil, water and air. For example, in some countries waste oil from vehicle servicing is usually taken by vehicle owners to be sold since there are no incentives for leaving the oil at the garage for safe disposal.

Sound oil management requires proper waste oil collection and transportation to designated storage sites and safe disposal in accordance with legislation. These three processes could be summed up conceptually as the waste oil management triangle, since they all are equally important in sound waste oil management. For instance, if oil collection is effective but the transportation and disposal components are not, the entire process will fail. In their self-assessment reports, some Member States, including Benin and Cameroon, highlighted the need to reduce exposure to hazardous chemicals from petrochemical spills and discharge of used oil.

Plastic waste

The manufacture of plastics and plastic-based substances has grown more quickly than any other sub-sector in Africa. Production of plastics utilizes many organochlorine compounds that are carcinogenic, such as vinyl chloride. Plastics are dangerous not just because they are non-biodegradable but also because the methods currently used in their disposal, mainly burning, make them so. The process of burning plastics generates many highly toxic chemicals including dioxins and furans, which are some of the compounds restricted under the Stockholm Convention. Tyre burning is usual in cities and townships. In their self-assessment reports, many Member States including Côte d'Ivoire, Lesotho, Madagascar and Nigeria noted that, as a significant contributor to air pollution, open burning of plastic waste was becoming a serious public health concern.

Many Member States have taken steps to ban or restrict the use of polyethylene carrier bags in their countries. This is an important achievement. The initiative to eliminate plastics by introducing alternatives needs to be implemented strictly and followed by all Member States. This move would greatly reduce dioxin emissions in the environment and sewer blockages, which if they hold water become breeding grounds for mosquitoes.

3.2.3 MANAGEMENT OF CONTAMINATED SITES AND FACILITIES

Exposure to chemical contaminants released from dump sites and facilities is a cause of public health problems in the African Region. For example, the Dandora waste dump site located in Nairobi, Kenya, is one of the most contaminated sites in Africa. According to UNEP, over 2 000 tonnes of domestic, industrial, agricultural, medical and other waste generated in the city is dumped at that site. As a result, the surrounding soil is highly contaminated with toxic chemicals including lead, cadmium and mercury.[161] According to a report by UNEP, of 328 children living around the dump site tested for chemical toxicity, almost half had respiratory diseases including chronic bronchitis and asthma, which are associated with toxic gases released from open burning of waste containing dioxins and furans.[162]

A study by IPEN examined samples of free-range chicken eggs from 17 countries, including four from the

Table 11: Dioxin and PCB levels in selected dump sites in the WHO African Region

Country	Sampling proximity	About the site	Level of contamination
Kenya	Waste dump	The Dandora dump is located in a densely populated residential area. The Nairobi River passes close by.	■ Dioxins: 7.6 times the EU limit ■ PCBs: 4 times the proposed EU limit
Mozambique	Cement kilns	The Matola cement kiln factory, also a location for obsolete pesticides stockpiles, is in the semi-urban zone close to the city of Maputo.	■ Dioxins: 1.7 times the EU limit ■ PCBs: 2 times the proposed EU limit
Senegal	Waste dump	The Mbeubeuss dump is used for both municipal and hazardous waste. It is on a lake bottom, and a part of it lies in groundwater.	■ Dioxins: 11 times the EU limit ■ PCBs: 1.7 times the proposed EU limit
United Republic of Tanzania	Obsolete pesticide dump	The Vikuge DDT site was used as a dump site for waste from Greece in 1980s. It has 282 000 ppm DDT in the soil. It is not fenced.	■ PCBs: 1.5 times the EU action level for dioxins

Region – Kenya, Mozambique, Senegal and Tanzania – collected near waste dumps, waste incinerators, cement kilns and chlorine production facilities to determine whether they contained dioxins or PCBs, because these facilities are known to be potential sources of unintentionally produced POPs.[162] The study focused mainly on locations in developing and transitioning countries because POP data is often lacking for these countries. Toxic levels of dioxins and PCBs were detected in the eggs from all four African Member States. The highest toxic levels of dioxins were registered in eggs collected near the Mbeubeuss dump site in Senegal and the Dandora dump site in Kenya, while the highest levels of PCBs were in eggs from near the Dandora dump site in Kenya and the Matola cement kiln factory in Mozambique (Table 11).

Comprehensive data on contaminated sites and facilities does not exist in the WHO African Region, because many Member States have either not conducted inventories or have not reported the findings for those inventories conducted. The self-assessment questionnaire asked Member States if they had inventoried their chemical stockpiles, waste deposits or contaminated sites. Of the 40 Member States responding, 30 (75%) indicated that they had conducted such inventories, four (10%) had not and six (15%) did not know if their countries had undertaken such inventories (Figure 22). The inventory data reported by Member States (Table 12) shows that stockpiles of POPs and obsolete pesticides are the main contaminators of the environment.

Figure 23: Inventories of chemicals conducted in the WHO African Region

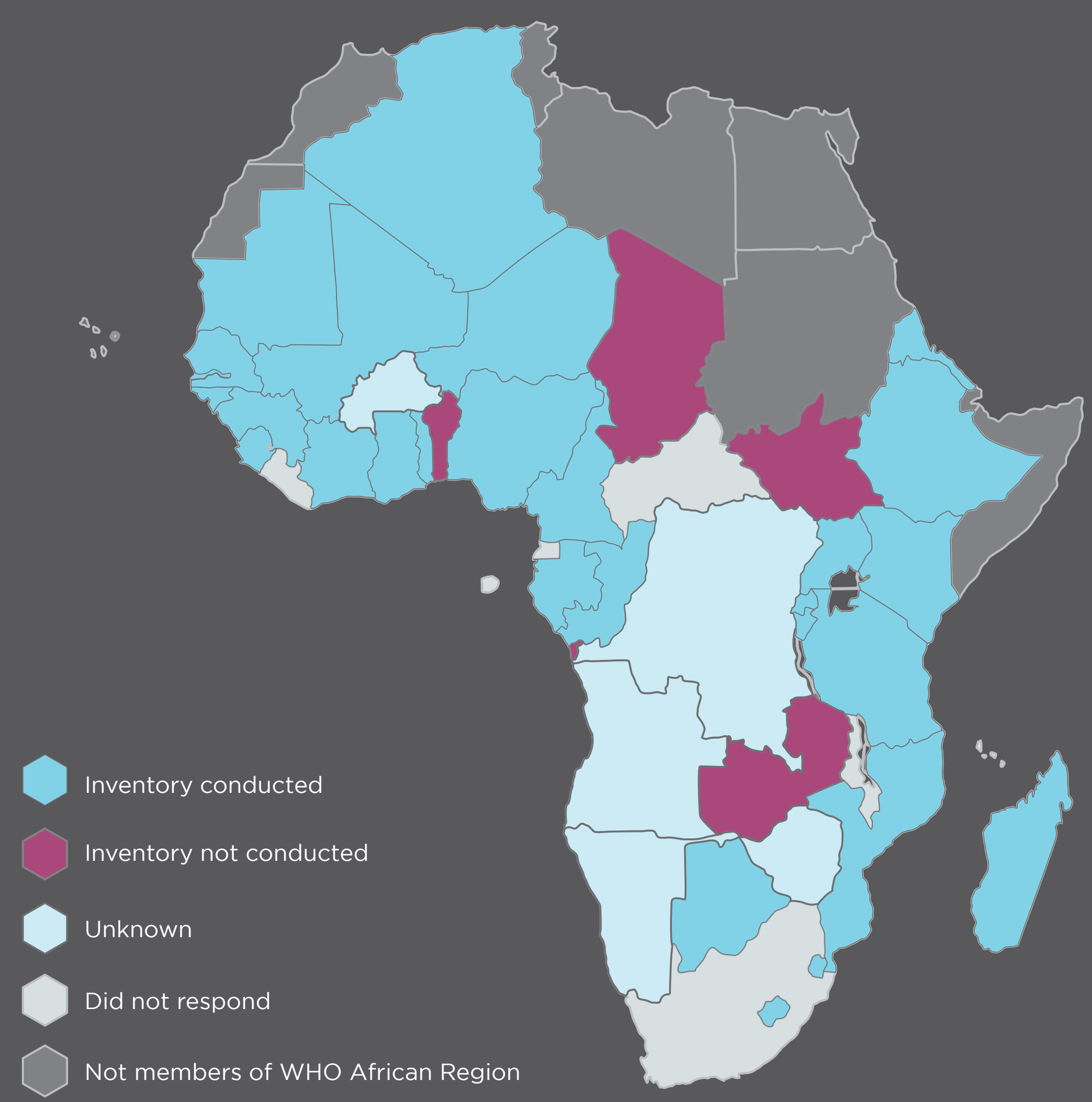


Table 12: Chemical stockpiles, contaminated sites and facilities reported by Member States

Country	Chemical stockpiles, contaminated sites and facilities
Algeria	2003 data shows 145 contaminated sites with 3.44 tonnes of PCBs, 1 731 tonnes of pesticides and TEQ 22 642.32/year of dioxins and furans.
Botswana	Two sites in Sebele and Kasene regions are contaminated with endosulfan.
Burundi	Six sites are contaminated with POPs and obsolete pesticides.
Cameroon	595 tonnes of obsolete pesticides, 1 tonne of POP pesticides, 54 000 empty pesticide containers and nearly 2 million tonnes of soil contaminated with POP pesticides.
Congo	2003 data shows existence of PCB contaminated sites and facilities.
Côte d'Ivoire	Partial inventory identified 413 transformers containing PCBs; several POPs (aldrin, chlordane, DDT, dieldrin, endrin, heptachore, hexaclorobenzene, mirex, toxaphene); and non-intentionally produced POPs (dioxins [polychlorinated-p-dioxin] and furans [polychlorinated dibenzofurans]). The quantities of the chemicals have not been reported.
Eritrea	Obsolete pesticides and veterinary products amounting to 335.4 tonnes and 21 tonnes of contaminated soil.
Ethiopia	An inventory had been conducted but the report on current stocks was not available.
Gabon	2007 data shows that 19 POP-contaminated sites have been identified with various obsolete chemical products (168.66 tonnes), battery nickel and cadmium deposits (8 tonnes), PCB-contaminated transformers (21 tonnes), waste asbestos (19 tonnes), various electrical and electronic equipment waste (192 tonnes), waste consisting of or contaminated with lead (186 tonnes) and chemical dispersants (12 tonnes).
Gambia	An inventory of DDT was recently conducted, but findings have not been reported.
Ghana	Partial inventories were carried out in 2008 of PCBs and pesticide contaminated sites, obsolete pesticides and empty pesticide containers, but figures were not provided.
Guinea	An inventory of PCBs and obsolete pesticides was conducted in 2003. Findings were not available.
Guinea-Bissau	An inventory was conducted but findings were not available
Kenya	An inventory was conducted but findings were not available.

Country	Chemical stockpiles, contaminated sites and facilities
Lesotho	The stockpiles identified were shipped to South Africa, but this does not rule out the re-emergence of new stockpiles.
Madagascar	Inventories were conducted of obsolete pesticides (1995), mercury release (2008) and PCBs, (period was not specified). The quantities were not reported.
Mali	2009 data shows that the country had 1100 tonnes of obsolete pesticides, 256 contaminated sites and 154 965 empty chemical containers.
Mauritania	Asbestos (4 tonnes), tetraethyl lead (28 000 litres), malathion (3 000 litres) and others.
Mauritius	From 2011 estimates, 16 800 tonnes and 252 m^3 of chemical waste were generated and recycled or disposed of.
Mozambique	An inventory was conducted but findings were not available.
Niger	An inventory was conducted but findings were not available.
Nigeria	An inventory of only government stores found 64.94 tonnes of obsolete pesticides, 14.80 tonnes of contaminated equipment, 66.1 tonnes of contaminated soil and about 1.712 tonnes of empty containers.
Rwanda	30 tonnes of obsolete pesticides, about 500 tonnes of PCBs of which 150 tonnes are PCB oils, and 350 tonnes of contaminated equipment.
Sao Tome and Principe	About 500 kg of DDT, large quantities of obsolete pesticides (exact quantities have not been identified) and some transformers containing PCBs.
Seychelles	Pesticides, PCB and other industrial chemical stockpiles are known to exist. Tests are under way to determine their quantities.
Sierra Leone	Studies have recently been conducted but results are not yet available.
Swaziland	5 818.5 litres and 1 092.5 kg of obsolete chemicals have been identified
Tanzania	An inventory has been conducted but findings have not been reported.
Togo	There are 8 potentially contaminated sites with 37 264 litres and 55 951 kg of POP pesticides, 1 386.17 tonnes of PCBs and 1 044.75 tonnes of other chemical waste.
Senegal	426.486 tonnes of obsolete pesticides have been collected, re-packed and shipped in containers to Hamburg, Germany for incineration

4 GAP ANALYSIS

4.1 STRENGTHS AND CHALLENGES IN THE MANAGEMENT OF CHEMICALS OF PUBLIC HEALTH CONCERN

Factors	Strengths	Challenges
Chemicals of major public health concern in the African Region	■ Chemicals of potential public health concern in the Region identified	■ Inadequate capacity for appropriate management of the identified chemicals
Potential sources of exposure	■ Potential sources of exposure defined for all major chemicals of public health concern ■ Elimination of the use of leaded petrol, a major achievement that has been successfully implemented in the majority of African countries	■ Limited knowledge of chemical risks ■ Inadequate resources for prevention of exposure to chemical
Legislation and policy	■ Implementation of the Libreville Declaration as it relates to chemicals management ■ Remarkable progress in the development of national legislation and policies by many Member States ■ International conventions, protocols, multilateral environmental agreements and non-binding legal agreements on chemicals management such as the Strategic Approach to International Chemicals Management (SAICM) policy framework that Member States have ratified	■ Many of the toxic chemicals concerned not taken into account in existing legislation ■ Poor implementation and enforcement of national legislation and MEAs
Coordination, collaboration and partnership	■ Formal and informal structures for collaboration of relevant sectors exist in many countries in the Region ■ Partnership with WHO, UNEP, SAICM and other bodies	■ Lack of mechanisms for coordination and collaboration among relevant sectors
Human resource capacity	■ Plans for development and strengthening of human resource capacity in many countries ■ The existence of national training institutions in many countries in the Region	■ Inappropriate allocation of existing human resources ■ An insufficient number of toxicologists
Surveillance capacity	■ IHR (2005), which covers chemical hazards and outbreaks of illness of public health importance of chemical aetiology	■ Environmental public health surveillance systems for chemical incidents generally absent ■ Inadequate collaboration among human surveillance units, poisons centres, chemical reference laboratories and relevant environmental sectors
Laboratory capacity	■ Existing reference laboratories in some Member States that deal with most chemicals identified as being of major public health concern	■ Inadequate laboratory equipment and essential reagents in existing national reference laboratories ■ Lack of regional external quality assessment programmes for chemicals of major public health concern
Capacity of poisons centres	■ International agencies willing to support the establishment and strengthening of poisons centres in the Region	■ Few countries have poisons centres or toxicology units with adequate resources
Management of chemical waste	■ National legislation on waste in many countries in the Region, plus the Basel and Bamako conventions that Member States have ratified	■ Growth of industries in Africa without appropriate infrastructure for chemical waste management
Management of chemical stockpiles, contaminated sites and facilities	■ International initiatives such as the African Stockpiles Programme that are supporting African countries in the disposal of existing obsolete stockpiles laboratories in some Member States that deal with most chemicals identified as being of major public health concern	■ Lack of chemical recycling and disposal facilities in the African Region

5 RECOMMENDATIONS AND PROPOSED ACTIONS

5.1 RECOMMENDATIONS

A Chemicals of major public health concern in the African Region

- Develop standards, regulations, guidelines and tools for the safe management of chemicals

B Potential sources of exposure

- Develop standard operating procedures for limiting occupational and environmental exposure
- Develop and disseminate health-promotion material in collaboration with relevant programmes

C Legislation and policy

- Develop strong enforcement mechanisms for implementation of existing legislation, including MEAs
- Develop comprehensive policies for an integrated approach to chemicals management using a life-cycle approach

D Coordination, collaboration and partnership

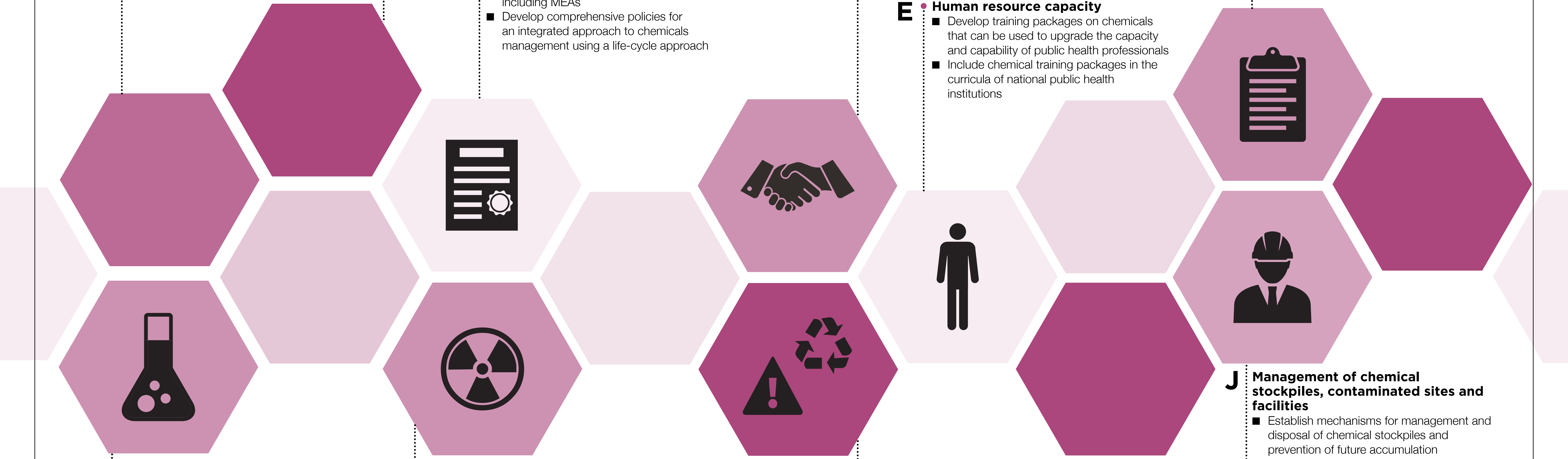
- Implement intersectoral coordination mechanisms for the safe management of chemicals
- National multisectoral task forces that deal with issues related to public health and the environment to include chemicals on their agenda
- Enhance regional partnerships to deal with chemical issues such as waste management and illegal transboundary movement of chemicals

E Human resource capacity

- Develop training packages on chemicals that can be used to upgrade the capacity and capability of public health professionals
- Include chemical training packages in the curricula of national public health institutions

F Surveillance capacity

- Enhance early warning systems for detecting chemicals of public health concern, for example, create or strengthen surveillance units, poisons centres or toxicology units, chemical reference laboratories etc.
- Conduct surveillance of chemical exposure for potentially exposed groups, especially the most vulnerable such as children and pregnant women
- Enhance surveillance capacity of countries for monitoring chemicals in the environment that could have an impact on human health
- Foster intersectoral collaboration in the sharing of information and surveillance data



G Laboratory capacity

- Develop at least the minimum capability for atomic absorption spectrometry for analysis of heavy metals in all countries in the Region
- Establish mechanisms for collaboration between national laboratories in different sectors working on chemicals
- Identify or establish regional reference laboratories for confirmation of chemicals of public health concern

H Capacity of poisons centres

- Utilize existing WHO guidelines to establish and equip poisons centres
- Map the capacities of existing poisons centres
- Develop regional guidelines for the establishment of new poisons centres
- Upgrade the capacities of existing poisons centres as necessary

I Management of chemical waste

- Identify the industries principally responsible for the discharge of toxic chemicals and implement strict regulatory mechanisms to control them
- Advocate appropriate recovery and recycling technology working in close collaboration with relevant stakeholders
- Develop promotional materials to enhance public awareness of waste management issues, for example on characterization of chemical waste
- Organize subregional training sessions on management of chemical waste in collaboration with national and international counterparts

J Management of chemical stockpiles, contaminated sites and facilities

- Establish mechanisms for management and disposal of chemical stockpiles and prevention of future accumulation
- Advocate decontamination of contaminated sites and facilities

5.2 PRIORITY ACTIONS

A Dissemination of this report to all relevant stakeholders

B In-depth on-site evaluation of chemical management systems in selected countries based on the findings of this report

C Elaboration of a regional 2015–2020 strategy for management of chemicals to address the issues and challenges identified in this report

D Development of norms and standards, where and as necessary, on the capacities required for chemical management, taking account of existing guidelines such as those of the Inter-Organization Programme for the Sound Management of Chemicals (IOMC), SAICM etc.

E Development of comprehensive training packages on chemical management for public health professionals, working in close collaboration with other WHO programmes and relevant stakeholders

F Provision of technical support to Member States for the implementation, monitoring and evaluation of the 2015–2020 regional strategy after its formulation

ANNEXES

Annex 1: Chemical incidents reported by responding Member States

Country	Chemical event	Period of event	Location	Cases/ fatalities
Algeria	Nitrate poisoning	2013	Chlef	Unknown
Angola	Lead poisoning	2012	Luanda	Unknown
	Bromide poisoning (table salt contaminated with sodium bromide)	2 November to 5 December 2007	Municipality of Cacuaco	467 people poisoned, mostly children
	Poisoning of unknown cause in schools	2011-2013	Luanda, Huila and Huambo	Unknown
Botswana	Occupational exposure to benzene	2002	Caratex locality, Gaborone	Unknown
	Methanol intoxication in students	2003	Macha Senior Secondary School, Kang	Unknown
	Inhalation of sodium hypochloride	2010	Poultry in Gaborone North	Unknown
Burundi	Aldicarb poisoning	2003	Bubanza, Bujumbura Rural in Western Burundi	10 fatalities
Cameroon	Pesticide poisoning	2004	Batcham in Ouest Province	4 fatalities
	Pesticide poisoning	2011	Penja in Littoral Province	No fatalities
Côte d'Ivoire	Probo Koala toxic waste poisoning (oil, hydrogen sulfide, phenols, caustic soda and organic sulphur compounds)	2006	Abidjan	43 492 cases confirmed, 24 825 probable cases and 17 deaths
	Cattle deaths related to the misuse of diazinon (external parasiticide)	1 May to 9 June 2013	Bouaflé, Bouaké and Korhogo	Approximately 100 cattle dead. No human deaths since the dead animals were destroyed quickly
	Sudden and massive mortality of fish on Lagoon Ebrié (pollution by pesticides and polycyclic aromatic hydrocarbons including benzo (a) pyrene)	17 May to 30 June 2013 6 July 2013	Layo and Dabou Layo	More than 60 people who consumed fish bought at a market in Dabou were poisoned
Ghana	Liquefied petroleum gas (LPG) explosion	2007 and 2014	Kumasi, Ashanti Region and Tema, Greater Accra	135 injured
	Explosion of chemical warehouse containing dimethoate (toxic pesticide) resulting in the release of toxic fumes	2012	Kumasi, Ashanti Region	Unknown number of cases, but odour created nuisance in Kumasi Metropolis

Country	Chemical event	Period of event	Location	Cases/ fatalities
Guinea	Discharge of waste oils	2013	Matoto in Matoto Town	Unknown
	Discharge of hydrocarbons	2009 and 2010	Kamsar, Boké and Friguiagbé, Kindia	Unknown
	Discharge of caustic soda	2011	Fria	Unknown
Kenya	Methanol poisoning	Recurrent episodes	Central, Nairobi, Eastern, Rift Valley provinces	At least 500 cases with 200 fatalities per year
	Accidental or suicide poisoning with agrochemicals and rat poison	Ongoing	Countrywide	1 479 cases and 579 fatalities in year 2012
	Poisoning related to chemicals	January 2005–March 2008	Bamako District in Koulikoro Region, and Sikasso and Ségou regions	520 cases
Mali	Poisoning of all causes	2010	Bamako District and Kayes, Koulikoro, Sikasso, Segou, Mopti, Gao and Timbuktu regions	6 953 cases, 8 deaths
Mauritius	Release of chlorine	2003	Albion, Black River	1 death
	Leakage of acetylene gas	2005	Grand River North West, Port Louis	School children admitted to hospital; no deaths
Namibia	Poisoning related to DDT and deltamethrine	Ongoing	All northern malaria-transmission regions of Kuene, Outapi, Oshana, Oshikoto, Kavango Zambezi and Otjozondijupa	Unknown
Nigeria	Lead poisoning	2010 to present	Zamfara State	355 cases, 183 deaths in 2010
	Pesticide poisoning from residue on crops	2012	Kaduna State	Unconfirmed number of hospitalizations
	Chemical explosion (bomb blast)	2002	Ikeja, Lagos State	Unknown
Sao Tome and Principe	Exposure to rat poison	2010–2013	Districts of Mézochi, Lobata, Cantagalo and Água Grande	5 cases
Senegal	Lead poisoning	2010	Mbao	22 children dead
	Lead poisoning	2008	Dakar Region, districts of Mbao and NGagne Diaw	18 children dead
	Pesticide poisoning (chlorpyrifos poisoning)	2002-2003 and 2009	Diannah, Ziguinchor	17 dead

Country	Chemical event	Period of event	Location	Cases/ fatalities
Senegal	Ammonia accident	1992	Dakar	128 dead, over 100 injuries
Seychelles	Accidental release of ammonia gas	Unknown	Port Victoria	No deaths reported
Tanzania	Accident involving truck carrying hydrochloric acid	2010	Lguguno	None
Uganda	Pesticide poisoning	2013	Pallisa	61 deaths
	Pesticide poisoning	2012	Wakiso	26 deaths
Zambia	Pesticide poisoning (aluminium phosphide)	2012	Chinsali, Muchinga Province	1 death
Zimbabwe	Haulage truck with hazardous substances	2012	Mvuma, Midlands	No deaths reported

Annex 2: Self-assessment tool on the impact of chemicals and systems for their management

Assessment tool on the impact of chemicals on public health and their management in the African Region

[Outil d'évaluation de l'impact des produits chimiques sur la santé publique et de leur gestion dans la région Africaine]

Contact information (Coordonnées de contact)

Name of the country (Nom du pays): ______________________________

Date: ______________________________

Name and title of respondent (Nom et titre du répondant): ______________________________

Telephone number [mobile] (Numéro de téléphone [portable]): ______________________________

Email: ______________________________

In filling this questionnaire, please involve the ministries/sectors/institutions that are involved in chemical event surveillance, management and response.

(En remplissant ce questionnaire, prière d'associer les ministères /les secteurs / les institutions qui sont impliqués dans la surveillance, la gestion et la réponse aux 'événements chimiques).

Section 1: Identification of chemicals of public health concern
(Identification des substances chimiques dont les effets sont préoccupants pour la santé publique)

1. Please list the different sectors (industry, agriculture, health, etc.) in your country that are the main users of chemicals. For each sector, please list the main chemicals used. According to your knowledge, which of the chemicals you listed are of public health concern to your country

(Prière d'énumérer les principaux secteurs (industrie, agriculture, santé, etc) dans votre pays utilisant souvent des produits chimiques? Pour chaque secteur identifié, prière de fournir la liste des principaux produits chimiques utilisés. Selon les informations que vous disposez et aussi votre expérience, pourriez-vous énumérés parmi les produits chimiques que vous avez mentionnés ceux qui posent un problème majeur de santé publique dans votre pays)?

Sector *(Secteur)*	Main chemicals used *(Principaux produits chimiques utilisés)*	Chemicals of public health concern *(Produits chimiques dont les effets sont préoccupants pour la santé publique)*

2.Has your country registered any chemical events in the last 10 years?

(Est-ce que votre pays a enregistré des événements chimiques au cours de ces 10 dernières années?)

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please provide the following information
(Si oui, prière de fournir les informations suivantes):

Chemical event [e.g. Lead poisoning] *(Événement chimique [ex. intoxication au plomb])*	Period of event [e.g 2011] *(Période de l'événement [ex. 2011])*	Region/district/province *(Région / district / province)*	Number of cases and fatalities *(Nombre de cas et de décès)*

3.Could you please verify if the following factors are potential sources of chemical exposure in your country

(Pourriez-vous vérifier si les facteurs suivants représentent des sources potentielles d'exposition aux produits chimiques dans votre pays)?

(a) Artisanal mining *(Exploitation minière artisanale)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please specify the chemicals (*Si oui, prière de préciser les produits chimiques concernés).*

____

____

(b) Use of hazardous pesticides in agriculture *(Utilisation des pesticides dangereux dans l'agriculture)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please specify the chemicals *(Si oui, prière de préciser les produits chimiques concernés).*

(c) Availability of contaminated consumer products (e.g. lead-containing paints, mercury-contaminated soaps, leaded petrol etc.) in your country (*Utilisation des produits contaminés dans votre pays (par example utilisation des peintures contenant du plomb , des savons contaminés par le mercure ou de l'essence au plomb, etc.)).*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please list the type of products available and the chemicals contaminating them *(Si oui, prière d'indiquer le type des produits disponibles et les produits chimiques responsables de leur contamination en eux).*

(d) Please describe any other potential sources of exposure to hazardous/toxic chemicals in your country *(Prière de décrire les autres sources potentielles d'exposition aux produits chimiques dangereux / toxiques dans votre pays).*

Section 2: Chemical management systems
(Systèmes de gestion des produits chimiques)

1. Are there laws/policies/regulations (state constitutions, laws, decrees or similar legal instruments) pertaining to the use and management of chemicals in your country *(Y at-il des législations/des documents politiques/une réglementation relatives à l'utilisation et la gestion des produits chimiques dans votre pays (par exemple des lois, des décrets ou des instruments juridiques))?*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please describe if the legislations/policies/regulations govern all chemicals (*Si oui, prière de décrire si les législations / les documents politiques / les règlements existants tiennent en considération tous les produits chimiques).*

2. Is there a mechanism, structure or body for coordination, collaboration and/or partnership for the identification and management of chemicals *(Existe t-il un mécanisme, une structure ou un organe de coordination, de collaboration et / ou un partenariat en charge de l'identification et de la gestion des produits chimiques)?*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please describe briefly *(Si oui, prière de décrire brièvement).*

3. Does your country have an adequately-resourced poisons centre/toxicology unit/case management centre *(Est-ce que votre pays dispose un Centre Antipoison / une unité de toxicologie / un centre de prise en charge avec une disponibilité des ressources adéquates/suffisantes)?*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please specify how many and describe their capacity briefly *(Si oui, prière de spécifier le nombre des centres existants et décrire brièvement leurs capacités)?*

4. Are there national chemical laboratories to monitor the chemicals in the following *(Y a t-il des laboratoires nationaux de chimie qui assurent les tests des produits chimiques ci-dessous)?:*

(a) Drinking-water *(Eau potable)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

Please list the main chemicals monitored *(Prière de fournir la liste des principaux produits chimiques testés au sein de ces laboratoires).*

(b) Food *(Aliments)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

Please list the main chemicals monitored *(Prière de fournir la liste des principaux produits chimiques testés au sein de ces laboratoires).*

(c) Soil/Geological sample *(Sol / échantillon géologique)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

Please list the main chemicals monitored *(Prière de fournir la liste des principaux produits chimiques testés au sein de ces laboratoires).*

5. Is there a capacity in terms of human resources to detect chemical events? *(Y a t-il des capacités en ressources humaines pour assurer la détection des événements chimiques?)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please describe briefly *(Si oui, prière de décrire brièvement).*

6. Is there a capacity in terms of human resources to detect chemical events? *(Y a t-il des capacités en ressources humaines pour assurer la détection des événements chimiques?)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please describe briefly *(Si oui, prière de décrire brièvement).*

7. Is there a national reference laboratory to confirm chemical events? *(Existe t-il un laboratoire national de référence pour assurer la confirmation des événements chimiques?)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, in order to help us assess the capacity of the laboratory, please specify if the laboratory is equipped with any of the following equipment. *(Si oui, pour nous aider à évaluer la capacité existence de ce laboratoire, prière d' indiquer s'il est équipé de l'un des équipements ci-dessous.)*

Atomic absorption spectrophotometer *(Spectrophotomètre d'absorption atomique)*	☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*
Flame photometer (*Photomètre de flamme)*	☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*
Gas chromatograph *(Chromatographe en phase gazeuse)*	☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*
High performance liquid chromatograph (HPLC) *[chromatographie en phase liquide à haute performance (CLHP)]*	☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*
Inductively coupled plasma-mass spectrometer *(Spectromètre de masse à plasma à couplage inductif)*	☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*
Infrared spectrophotometer *(spectrophotomètre infrarouge)*	☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*
X ray spectrometer (XRD) *[X spectromètre à rayons X (XRD)]*	☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

8. Is the laboratory affiliated with external laboratories for further testing or confirmation of chemical events? *(Est-ce que le laboratoire est affilié à des laboratoires extérieurs pour effectuer des tests additionnels ou assurer la conformation des événements chimiques?)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please provide the name of the laboratory (ies). *(Si oui, prière de fournir le nom du/des laboratoire(s)).*

Section 3: Management of chemical waste
(Gestion des déchets chimiques)

1.Are there laws/policies/regulations (state constitutions, laws, or similar legal instruments) pertaining to the use and management of chemical waste in your country? *(Y a t-il des législations/des documents politiques/des réglementations (des lois, ou des instruments juridiques) sur l'utilisation et la gestion des déchets chimiques dans votre pays?)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please describe if the laws/policies/regulations govern all chemical waste. *(Si oui, prière de décrire si les législations / les documents politiques/les règlements en question tiennent en considération tous les déchets chimiques?)*

2. Are there any facilities in your country for recycling or recovery of chemicals and related waste? *(Y a t-il des infrastructures/une installation au niveau du pays en charge du recyclage ou de la récupération des produits chimiques et des déchets afférents?)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please describe the type of facilities briefly. *(Si oui, prière de décrire brièvement le type d'infrastructures disponibles.)*

3. Are there facilities for disposal of chemicals and related waste in your country? *(Y a t-il des infrastructures/une installation d'élimination des produits chimiques et des déchets afférents dans votre pays?)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please describe the type of facilities. *(Si oui, prière de décrire le type d'infrastructures disponibles.)*

4. Has there been an inventory of stockpiles, waste deposits and contaminated sites in your country? This may include an inventory of POPs and PCBs. *(Y a t-il eu un inventaire des stocks, des dépôts de déchets et des sites contaminés des produits chimiques dans votre pays? Cet inventaire peut inclure celui des POP et des PCB.)*

☐ Yes *(Oui)* ☐ No *(Non)* ☐ Don't know *(Inconnu)*

If yes, please describe the findings in brief. Please include any quantitative data on chemical stockpiles if available. *(Si oui, prière de décrire brièvement les résultats obtenus. Aussi, prière d'inclure toutes les données quantitatives sur les stocks existants de produits chimiques si cela est disponible.)*

5. Please provide any comments or clarification to the questions above and list any relevant information which is not reflected in this questionnaire. *(Prière de fournir des commentaires ou des clarifications sur les questions ci-dessus et aussi fournir toutes les informations pertinentes qui ne sont pas reflétées dans le présent questionnaire.)*

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