The International POPs Elimination Project (IPEP)

Fostering Active and Effective Civil Society Participation in Preparations for Implementation of the Stockholm Convention

Inventory of some informal sector activities releasing POPs in Senegal

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May 2006

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- Encourage and enable NGOs in 40 developing and transitional countries to engage in activities that provide concrete and immediate contributions to country efforts in preparing for the implementation of the Stockholm Convention;

- Enhance the skills and knowledge of NGOs to help build their capacity as effective stakeholders in the Convention implementation process;

- Help establish regional and national NGO coordination and capacity in all regions of the world in support of longer term efforts to achieve chemical safety.

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IPEN gratefully acknowledges the financial support of the Global Environment Facility, Swiss Agency for Development and Cooperation, Swiss Agency for the Environment Forests and Landscape, the Canada POPs Fund, the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM), Mitchell Kapor Foundation, Sigrid Rausing Trust, New York Community Trust and others.

The views expressed in this report are those of the authors and not necessarily the views of the institutions providing management and/or financial support.

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I- Background and objectives

The informal sector seems to be in Senegal, along with the state, the main provider of jobs and income. In 1991, the sector accounted for 58.7 percent of the active urban population with a growth 1.8 times faster than the modern sector from 1986 to 1991. However, despite its dynamism and importance for the Senegalese economy, there are many grievances against the informal sector. In general, the activities of the informal sector are conducted away from the criminal, social and fiscal framework and do not comply with any environmental or sanitation standard. That is why they are sources of environmental and public health problems through their modus operandi and substances used. That is the case of Senegal where many activities of the informal sector are suspected to be potential sources of dioxins and furans.

Senegal ratified the Stockholm Convention on Persistent Organic Pollutants (POPs) in October 2003. With the coming into legal force of the Convention since 17 May 2004, Senegal as a party to the Stockholm Convention has taken some measures aimed at implementing it.

As part of the preparatory work on the National Implementation Plan (NIP) of the Stockholm Convention, an inventory of POPs in Senegal has been made. However, the inventory of POPs had not enabled the identification all the sources of POPs or quantification of the volumes discharged by the informal sector. It is in this context that the NIP, in response to Article 5 of the Stockholm Convention has planned to make a more detailed inventory of unintentionally produced POPs by including in this inventory other relevant sources such as, motor vehicles, sources of residential combustion and the informal sector.

This study aims at contributing to the identification of the sources and quantification of discharges of dioxins and furans in the informal sector. The specific aims of the study are as follows:

- Identify potential sources of dioxins and furans in the Senegalese informal sector.
- Conduct the first test of the specialised tool (Toolkit) to identify and quantify discharges of dioxins and furans in the informal sector. This tool has been developed by UNEP Chemicals to help countries make their inventory of dioxins and furans.
- Make recommendations for the improvement of the Toolkit and facilitate its use in the informal sector of Senegal.

II - Methodology

The methodology used in this study has been mainly based on the second version of the Toolkit for the identification and quantification of discharges of dioxins and furans of February 2005. As recommended by the Toolkit, we have used the following methodology:

- Identification of the business groups in the informal sector which may potentially produce and generate dioxins and furans: the purpose was to identify the main Categories of Main Sources of PCDD/PCDF existing in the informal sector of Senegal and divide these Categories of Main Sources into Sub-Categories so as to identify the individual activities which are likely to discharge dioxins and furans.

- Collection of information related to production processes to characterize, quantify and finally classify the identified sources of discharges of PCDD/PCDF in the informal sector. Standardized questionnaires, inserted in the toolkit have been used and adjusted to get the needed information.
- Assessment of discharges on the basis of information collected from previous steps, thanks to the equation (1) below.
- The last stage consisted of compiling the standardized inventory of PCDD/PCDF, by using the results produced in stages 1 to 4

III- Results

The main types of activities of the Senegalese informal sector which are potentially sources of dioxins and furans are:

- Artisan smelting plants
- Lead extraction from motor vehicle batteries
- The burning of wastes
- Iron extraction from tyres
- The smoking of skins

All these types of activities have something in common: the use of combustion in their production processes. Besides, combustion is an open process and the materials burnt are metals and other items contaminated by oils, paints and other pollutants, and / or contain PVC plastics or are semi-ligneous products. In addition to these activities, there are other activities of the informal sector which may be potential sources of dioxins and furans. They relate indeed to any other activities using charcoal and other ligneous products as fuels.

3-1 Smelting plants

3-1-1 Description of the activities of smelting plants

Most of the time, the raw materials used are aluminum. The collected aluminum is classified into two categories: light and heavy aluminum. Light aluminum is in general made of packages of drinks and canned fish, tomato, milk and other food produces. They mainly come from municipal landfill sites. As for heavy aluminum, it is made of motor vehicle machine parts and other big parts wholly or party made of aluminum.

The melting is done at temperatures close to 650°C. The kiln is made out of the cover of iron drums which is cut and folded to make it a container. It is placed into a big hole filled with charcoal used as fuel and poked up with a fan blower. The materials melt and are mixed without distinction of their component, a ladle is used to remove dirt from the surface.

The slag deriving from the melting is retrieved and melted again in kilns to extract the aluminum it contains so as to maximize the outputs of the melting process. When the slag does no longer contain enough aluminum, it is left as waste in the vicinity of smelting plants. It is extracted during the rainy season, by resident populations and smelter men themselves to

backfill the soil so as to prevent floods because the site is liable to flooding. Thus, with this process, there is a risk of contamination of the land and ground waters.

3-1-2 Discharges of dioxins and furans by artisan smelting plants

Measuring the environmental impact of artisan aluminum smelting plants by using the Dioxins Toolkit is not an easy thing for many reasons:

- At first, the toolkit in the **« Main Category 2 : Production of ferrous and non ferrous metals »** only covers aluminum industries (formal sector) using more advanced materials and processes (pre-processing of aluminum wastes, kilns with filters etc.) than those used in artisan smelting plants;
- The burning processes selected in the toolkit for the production of aluminum are performed in a closed area whereas **aluminum melting in the informal sector is an open-air activity** ;
- The section of the toolkit relating to open-air burning processes **« Category 6: Uncontrolled burning processes »** does not deal with the melting of scrap metals for the extraction of aluminum.

Thus, for the assessment of discharges of dioxins and furans by secondary artisan aluminum smelting plants, we have taken into account a certain number of items.

- One of the causes of the potential generation of dioxins and furans by artisan aluminum smelting plants is the melting of aluminum wastes contaminated by oils, PVC plastic, paints and other chlorinated and organic pollutants. Indeed, according to interviewed smelter men, any types of aluminum are extracted, including coils of condensers of which sheets are generally covered by oil (PCBs not excluded because the types of oils are not defined), machine parts and other materials contaminated by paints, PVC and other chlorinated and organic pollutants.
- Fires of landfill sites themselves present the same precursors of dioxins and furans as open-air artisan smelting plants (without pre-processing of the raw material, without control and gas scrubbing systems and other emissions), bad burning conditions, and mixed wastes, materials contaminated by chlorinated and organic pollutants.
- We have also included the fuel used as source of dioxins and furans. Indeed, they use charcoal and wastes of ligneous objects (scraps of doors, windows and other wooden objects).
- Though there is a high risk of discharges in products and soils as well as ground waters because of the use of slag and other residues to backfill the soils and fight against floods, the assessment included only discharges in the air and residues. In the Toolkit, solid residues generated by industrial or household activities such as slag, fly ashes or mud are classified as wastes because they are produced as such in the process.

So, we have selected as part of this assessment emission factors of landfill site fires for emissions generated by the melting process of materials and kilns to wood or contaminated biomass. These emission factors, though not wholly assessing the quantities of dioxins emitted by artisan aluminum smelting plants, could represent a valid estimate of discharges of this industry.

Table 1: Emission factors selected * to assess discharges of PCDD/PCDF in the industry of artisan aluminum smelting plants

Categories of sources	**Vectors of potential discharges (µg TEQ/t)**				
	Air	Water	Land	Products	Residues
Melting of aluminum wastes	1 000	ND	ND	ND	600
Fuel (Charcoal or contaminated biomass products)	100	ND	NA	NA	10 ng TEQ/kg of ash

*Emission factors obtained by extrapolation

3-2 Lead extraction from motor vehicle batteries

3-2-1 Description of the activity

Batteries are ripped open with rudimentary tools and the contents are dumped on the ground to extract the acid inside. The following step consists in segregating lead meshes from the case bound paper or other items. Then, the lead meshes are cleaned to remove any dirt. The lead meshes are put into a container and melted at high temperatures. The burning of batteries is done with wood, plastic carcasses of batteries and other plastics. To better optimize the fire, drain oil is often poured on the fire which contributes to increasing the potential of emission of PCDD/PCDF of this activity.

The extracted lead is sold at around 200 CFAF (0.4$ US) per kilogramme. The lead is sold to traditional fishermen who as good artisans process it into sinkers meant to ballast fishing nets.

3-2-2 Discharges of dioxins and furans by the activities of lead extraction from motor vehicle batteries

The emissions of PCDD/PCDF may be linked to the significant presence of organic materials fixed on wastes and the presence of chlorine; in particular a link has been made between the use of separators of PVC in batteries for vehicles and the emissions of PCDD/PCDF.

As for previous activities, the Toolkit does not include emission factors for the extraction of lead from motor vehicle batteries as practiced in the Senegalese informal sector. The emission factors proposed by the Toolkit have been defined on the basis of a kiln for the melting of secondary lead as part of the project funded by Thailand on the UNEP 2001 Sampling and Analysis of Dioxins which has characteristics totally different from the extraction process of lead from motor vehicle batteries.

Lead extraction in Senegal covers the following features:

- Lead extraction is performed in the open air ;
- The required energy for the secondary melting of lead results from the burning of contaminated wood (because it comes from recycled wooden objects), plastic carcasses of

batteries and other plastics to better optimize the energy, the drain oil is systematically poured on the fire.

- Likewise, the lead contained in meshes as well as battery poles which are extracted and the meshes are segregated from case bound papers and other dirt which could be precursors to the formation of dioxins and furans.

Thus, the potential generation of dioxins and furans as part of lead extraction from motor vehicle batteries in Senegal would be linked to fuels used for the melting of battery items. The difficulty of assessing emissions of PCDD/PCDF lies in the fuels which are used since they are a mixture of wood, plastics and used oil in volumes which cannot be easily estimated. Since emission factors cannot be duly determined, we can assume that the fuels used are a representation of domestic wastes. In this respect, emission factors from the burning of domestic wastes in the open air proposed by the Toolkit can give an idea of the level of emission of this activity. Indeed, these emission factors have been defined on the basis of the burning of wastes made up of a variety of items, including plastics and objects such as hazardous domestic wastes like chemicals.

Table 2: Emission factors selected * to assess discharges of PCDD/PCDF in artisan activities of lead extraction from motor vehicle batteries

Categories of sources	**Vectors of potential discharges (µg TEQ/t)**				
	Water	Land	Products	Residues	Air
Fuels (contaminated wood, plastics and used oils)	300	NA	600	NA	600

* These are emission factors proposed by the Toolkit for the burning of domestic wastes in the open air

3-3 Skin smoking

3-3-1 Description of the skin smoking process

Smoking meat and fish to preserve it is a common practice in numerous developing countries. In Dakar, skins of sheep and bulls are smoked.

The skins are dried 1 to 2 weeks prior to smoking. Once dried, they are laid on a mesh to be smoked. Motor vehicles tyres are the main fuels used for skin smoking. The burning of skins generates an important discharge of PCDD/PCDF. There is a real risk of intoxication by dioxins and furans for skin smokers and resident populations. Besides, there is a risk of contamination of the smoked skins by dioxins because only a mesh separates skins from burning tyres. Smoking is performed in the open air. It lasts nearly five minutes per item and takes place only in morning times. Smoked skins are exported in sub regional countries and are intended for consumption.

3-3-2 Discharges of dioxins and furans by skin smoking activities

The main potential source of dioxins and furans of skin smoking in Senegal would be tyres used as fuels. Indeed, skins are not burnt; they are only smoked for nearly 5 minutes. Thus, the risk of formation of dioxins derives from the fuel used; that is to say motor vehicle tyres.

In the Toolkit, emission factors into the air of smoking activities relate to the use of wood as fuel or in the case of the Senegalese informal sector, the tyres which are used. If there are no default emission factors, those of accidental fires in vehicles could be used.

The burning of tyres as a source of energy for the smoking of skins is done on the ground and this could bring about a discharge of dioxins and furans in the soil. Besides, contaminated residues of the burning are left on site and when they scatter, they contribute to the discharge of PCDD/PCDF on the ground.

There is a high risk of discharge of dioxins and furans on smoked skins and it would be interesting to assess it. Indeed, smoked skins are in direct contact with burning tyres and only a mesh separates them.

Table 3: Emission factors selected * to assess discharges of PCDD/PCDF in artisan activities of skin smoking in Senegal

Categories de sources	**Vectors of potential discharges (µg TEQ/t)**				
	Air	Water	Land	Products	Residues
Smoking of skin with tyres as fuels	23,5	NA	4,5	ND	4,5

* These are emission factors of accidental fires of vehicles which have been divided into four (four tyres) because the rates given in the Toolkit are per vehicles

3-4 Iron extraction from tyres

The scrap dealers of Senegal are also interested in the iron contained in tyres. For that purpose, tyres are completely burnt to access the iron. In Dakar, this activity is performed in the landfill site of Mbeubeuss and in Hann on the beach.

3-4-1 Discharges of dioxins and furans

The impacts are similar to that of skin smoking where the main potential source of discharges of PCDD/PCDF remains the burning of tyres used as fuels. However, for this activity, discharges in products could relate to the extracted scrap.

3-5 Waste burning

3-5-1 Description of salvage activities in the landfill site of Mbeubeuss

Faced with a growing poverty and the extension of slums in the outskirts of the city of Dakar, people affected by economic difficulties have started moving around what has become today a real economic activity: waste retrieval and recycling.

Each scrap dealer has a specialty: glass, plastics, material or iron… Scrap dealers burn wastes to extract the ferrous or non ferrous items they contain or to reduce the volume of wastes. Apart from the voluntary burning of wastes, there are permanent phenomena of waste self burning. Thus, day in day out, throughout the whole year and over the whole landfill site, wastes are burning. This burning is slow and seems incomplete because of the permanent presence of smoke on the site. Among these wastes there are oil flows, derelict motor vehicles, carcasses of animals, irretrievable electronic equipment, industrial wastes, medical wastes, plastic satchels and bags, used tyres, cables etc.

3-5-2 Discharges of dioxins and furans in the landfill site of Mbeubeuss

The landfill site of Mbeubeuss receives a variety of wastes which are burning on a daily basis. This landfill site presents the characteristics of landfill sites described in the Toolkit. The emission factors proposed in the Toolkit for burning landfill sites may well assess the emissions of PCDD/PCDF in Mbeubeuss.

Although the Toolkit has not given emission factors for discharges in the water and products, there is a certain risk of discharges in those matrices which is worth assessing.

The different soils observed in the landfill site are characterized by a very high permeability and consequently are not fit to be the background for a public landfill site[1]. Thus, during the rainy season, there is a major ingress which leads to a transfer of leachates towards the subsoil and groundwater. An impact assessment of the landfill site carried out in 1990 by the Environment Ministry showed already that the fresh water originating from the groundwater was polluted by the leachates of the public landfill site over a wide range (around 30 kilometres). **Thus, there is a high risk of discharge of dioxins and furans in groundwaters.**

Many items leave the landfill site of Mbeubeuss to be recycled in economic circuits. There is a high risk of dioxins and furans discharges on products leaving Mbeubeuss. Likewise, near the landfill site, there are major economic activities such as poultry farming and market gardening, etc. The products deriving from these activities may be also contaminated by the dioxins and furans generated by the landfill site. A study carried out in 2005 by the International POPs Elimination Network (IPEN) Pan Africa and ARNIKA found that eggs from chicken raised in the open air near the landfill site of Mbeubeuss had dioxin levels 11 times higher than the limit in force in the European Union and levels of polychlorinated biphenyls (PCBs) that were 1.7 times higher that proposed limits. The most obvious potential source of this contamination would be the burning of wastes containing chlorine such as PVC plastics frequently found on the landfill site and their uncontrolled burning.

Table 4: Emission factors selected * to assess emissions of PCDD/PCDF in the landfill site of Mbeubeuss

Categories of sources	**Vectors of potential discharges (µg TEQ/t)**				
	Air	Water	Land	Products	Residues
Fires of landfill sites	1 000	ND	4,5	ND	4,5

* These are emission factors of landfill site fires given by the Toolkit

3-6 Consumption of ligneous fuels

3-6-1 Description of the sector

Energy from wood is holding a key position in Senegalese energy consumption. A survey carried out in 1997 had found that charcoal and firewood accounted for respectively 16% and 40% of the Senegalese energy consumption meaning a total of 56% for ligneous fuels. This highlights the importance of the consumption of ligneous fuels in Senegal, especially in urban areas, notably Dakar which absorbs 79 100 tons meaning more than half of the consumption of charcoal and 22 100 tons for firewood[i]. Ligneous fuels are mainly used for household purposes: cooking, ironing, and heating.

The domestic sector is not the only consumer of ligneous fuels. The artisan as well as industrial sectors do consume them. Although their consumption has not been subject to a comprehensive assessment, it is estimated that presently they are very low and represents about 5% of the energy consumption. The most important artisan sector, in terms of consumption of ligneous fuels, is urban popular catering (cheap restaurants, “tanganas” and houses selling grilled meat). Their annual consumption is estimated at 4 200 tons of firewood and 3 600 tons of charcoal. The other artisans using these fuels are tailors, launderers, dyers of material, smelters of cooking pots, blacksmiths and jewelers. The consumption of the rural craft industry – production of palm oil and soap, fish smoking – are not very well known.

3-6-2 Discharges of dioxins and furans because of the use of domestic fuels

PCDDs/PCDFs are formed in a complex process during burning. Indeed, the devices for the use of ligneous fuels (household furnaces, traditional ovens etc.) do not allow complete burning and there are no systems to control and correct discharges.

In the Toolkit, a difference is made between pure biomass and contaminated biomass, for example processed or painted wood and straw heavily loaded with chlorinated pesticides. The air, residues and in some cases the soil are vectors of discharge to be considered. We assume that ligneous fuels used in Dakar are pure and deprived of any contamination because of their origins: forest surfaces which do not use in general pesticides or other chemicals in Senegal.

Table 5: Emission factors for heating and household kitchens using biomass

Categories of sources	**Vectors of potential discharges (µg TEQ/t)**				
	Air	Water	Land	Products	Residues
Kilns or furnaces burning pure biomass	100	NA	ND	NA	20

Sources: UNEP Toolkit, 2nd version

Table 6: Compilation of some sources of dioxins and furans released in the informal sector in the city of Dakar

Category of sources	**Vectors of potential discharges**					**Quantity of materials (T)**	**Wastes (annual)**					
	µg TEQ/t	µg TEQ/t	µg TEQ/t	µg TEQ/t	µg TEQ/t		g TEQ/an	g TEQ/an	g TEQ/an	g TEQ/an	g TEQ/an	**Total**
	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues	
Smelting plants							**10,1878**	**0**	**0**	**0**	**5,82544788**	**16,0132479**
Melting of aluminum wastes	1 000	ND	ND	ND	600	9709	9,709	ND	ND	ND	5,8254	15,5344
Fuel (Charcoal or contaminated biomass products)	100	ND	NA	NA	10 ng TEQ/kg de ash	4788	0,4788	ND	NA	NA	0,00004788	0,47884788
Lead extraction from motor vehicle batteries							**0,009**	**0**	**0,018**	**0**	**0,018**	**0,045**
Fuels (contaminated wood, plastics and used oils)	300	NA	600	NA	600	30	0,009	NA	0,018	NA	0,018	0,045
Smoking of skin							**0,1286625**	**0**	**0,0246375**	**0**	**0,0246375**	**0,1779375**
tyres as fuels	23,5	NA	4,5	ND	4,5	5475	0,1286625	NA	0,0246375	ND	0,0246375	0,1779375
Iron extraction from tyres							**0,1306177**	**0**	**0,0250119**	**0**	**0,0250119**	**0,1806415**
Burning of tyres	23,5	NA	4,5	ND	4,5	5558,2	0,1306177	NA	0,0250119	ND	0,0250119	0,1806415
Mbeubeuss landfill site							**365**	**0**	**1,6425**	**0**	**1,6425**	**368,285**
Fires of landfill sites	1000	ND	4,5	ND	4,5	365000	365	ND	1,6425	ND	1,6425	368,285
Use of domestic (ligneous) fuels							**0,78**	**0**	**0**	**0**	**0,156**	**0,936**
Kilns or furnaces burning pure biomass	100	NA	ND	NA	20	7800	0,78	NA	ND	NA	0,156	0,936
Total							**376,23608**	**0**	**1,7101494**	**0**	**7,69159728**	**385,637827**

Recommendations

If we have managed to identify several sources of emission of dioxins and furans in the informal sector of Senegal, the estimate of discharges of these toxic substances is not easy. Indeed, most of the data available on discharges of dioxins and furans relate to industrial technologies used mostly in developed countries and presenting a certain number of characteristics that do not have the technologies used in the Senegalese informal sector. For that reason, it is critical to carry out assessments of discharges of dioxins and furans with the technologies used in developing countries and more particularly in informal activities. For that purpose, there is a need to:

1. **Improve the awareness on potential sources of discharges of dioxins and furans in the informal sector**

To achieve that we should:

- Identify all the categories of activities of the informal sector which are potential sources of dioxins and furans; this is critical for any comprehensive inventory of discharges of dioxins and furans by the informal sector
- Make a comprehensive inventory of all the activities of the informal sector in Senegal
- Conduct a characterization of the technologies used by these activities: the purpose is to know all the types and quantities of raw materials used, the technologies used, combustion temperatures
- Characterize all the wastes dumped in landfill sites. The purpose is to know the composition of wastes and the quantities of the different components of wastes, which will allow an identification of their potential of discharge of dioxins and furans. Open dumps are the main sources of dioxins and furans in many African cities. A method used for the characterization will consist in quantifying manually the wastes of a sample of representative households of the city of which the landfill site receives

2. **Improve the awareness on discharges of dioxins in the activities of the informal sector in the different environmental matrices : air, ground water, products, residues**

- Implement sampling and analysis projects of dioxins and furans for some main activities of the informal sector such as melting in the open air and in traditional kilns of metal objects for the secondary production of aluminum, copper, iron, lead, and the smoking of skins by using tyres or chlorinated objects as fuels
- Carry out an assessment of discharges of dioxins in smoked skins because these products are intended for consumption so as to determine their level of contamination
- Carry out an assessment of discharges of dioxins in the products of artisan smelting plants used in all the Senegalese households for the preparation of meals and to preserve food. In this respect, an analysis of the wash waters of these utensils would enable to get a fairly accurate idea of their level of contamination by dioxins and furans
- Carry out an assessment of discharges of dioxins and furans in ground waters because of the use of slag and other residues of the artisan and secondary production of aluminum to backfill soils
- Assess discharges of PCDD/PCDF in the groundwater table under landfill sites because transfers of leachates towards the subsoil and the groundwater table are potential ways of emissions of dioxins and furans towards groundwaters.

- Carry out an assessment of discharges of dioxins in the items produced in the vicinity of the landfill site of Mbeubeuss : poultry and market gardening produce

3. Assess the level of contamination of the populations who are in direct or indirect contact with the activities of the informal sector : professionals of the sector and populations living around the sites where are performed these activities

4. Take measures to reduce and ultimately eliminate the production of dioxins and furans in the informal sector

- Sensitize the authorities about the hazards posed by dioxins and the potential production of substances which have an adverse effect on those activities
- Sensitize the actors of the informal sector about the hazards to which are exposed the populations or themselves as a whole
- Redirect these actors from the informal sector to other cleaner activities and train those who want to stay in this sector on cleaner technologies by using the guidelines on the best technologies available and the best environmental practices
- Help the actors of the informal sector improve their production technologies by developing a support programme for the purchase of more efficient equipments for the recycling of wastes