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STATUS OF IMPLEMENTATION OF THE TECHNICAL ASPECTS OF PROTOCOLS AND LEGALLY BINDING MEASURES ADOPTED IN THE FRAMEWORK OF ARTICLE 15 OF THE LAND-BASED SOURCES PROTOCOL

(REPORT PREPARED BY MED POL AND CP/RAC)

Delegates are kindly requested to bring their documents to the meeting

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Introduction

This document aims at bringing to the attention of the MED POL Focal points a number of issues related to the technical implementation of the Land based Sources and Activities (LBS), Dumping and Hazardous Waste (HW) Protocol. This report will address the following issues:

a) Implementation of the technical aspects of LBS, Dumping and HW Protocols implementation and data gap general analysis
b) Facilitate the Regional Plans Implementation and Reporting with a particular focus on potential synergies with the forthcoming global treaty on Mercury and Draft guidelines on Best Environmental practices for the sound management of mercury contaminated sites
c) Up to date tools to control and assess marine pollution (ELV/EQO and Nutrient Riverine Inputs Data base)

I. Implementation of the technical aspects of LBS, Dumping and HW Protocols implementation and data gap

a) General analysis

1.1 The Secretariat reviewed the reports submitted by the Contracting Parties on measures taken during 2008-2009 biennium for the implementation of the three Protocols and prepared a note for the Coordinating Unit. The focus was on the technical aspects of implementation. The main findings may be summarized as follows.

- *In total 15 CPs have submitted reports covering information partially or fully the technical aspects of the implementation of the 3 Protocols (excluding the EU).*

- *The information provided in the different parts of the reporting questionnaire differ for each Protocol and the Contracting Parties*

- *There is substantive improvement with regard to reporting of **technical data** compared to the previous biennium in terms of items reported, and number of Contracting Parties providing information*

- *Yet, a considerable number of Contracting Parties did not fill in important parts of the reporting format related to the technical aspects of the implementation of the three Protocols,*

- *A considerable number of countries report difficulties of an administrative and financial nature, as the main challenges for taking the necessary measures dealing with the technical aspects of implementation provided for in the 3 Protocols as well as the need for technical assistance*

2. Dumping Protocol

The Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft (Dumping Protocol), the original version of which came into force in 1978, was amended in 1995. The amended Protocol for the Prevention and Elimination of Pollution in the Mediterranean Sea by Dumping from Ships and Aircraft or Incineration at Sea has been ratified by 15 parties but has not yet entered into force.

The main technical aspects of the implementation of the Dumping Protocol for which the Contracting Parties should submit reports are related to:

- *permitting system, including respective institutional structures in charge of permitting*
- *monitoring to guide and control dumping activities when allowed by the Protocol,*
- *recording the number of permits issued, including details required by the Protocol on location of dumping, nature of substances, etc*
- *recording and reporting quantities of dumped materials,*
- *reporting the quantities of waste and materials dumped because of force majeure,*
- *implementing the guidelines adopted by the Contracting Parties meetings in 2003 and 2005 as provided in the Protocol with regard to dumping of 4 categories of materials*
- *Reporting enforcement and effectiveness indicators.*

Main findings: Several Contracting Parties are complying with the requirements of the protocol banning dumping in the sea, but some of them provide no information on the number of permits issued or their specifications such as the quantity of dumped materials. Neither do they give any information on the implementation of the guidelines adopted by the Meeting of the Parties in 2003 and 2005 on both the dumping of the four categories of materials authorized by the amendments to the Protocol, or on the application and the effectiveness of the indicators.

1- Several Contracting Parties report that they do not dump any materials.

2- Some of them do not report the number of permits and the specifications of quantities of the materials dumped.

3- Most of the Contracting Parties do not provide at all any information on the implementation of guidelines adopted by the Contracting Parties, with regard to dumping of 4 categories of materials allowed by the amendments to the Protocol as well as any information on enforcement and effectiveness indicators.

In some cases it is not always clear whether the Contracting Parties are reporting on the permits issued for materials, based on the provisions of the current Protocol in force or on its amendments that are not yet in force.

3. LBS Protocol

The original version of the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (LBS Protocol) was adopted in 1980 and was then amended in 1996. The amended Protocol has been ratified to-date by 17 Contracting Parties and it entered into force in 2008.

The LBS Protocol provides for the Contracting Parties to take and report on a number of measures related to:

- *Establishing permitting system*
- *Establishing inspectorate and enforcing national legislation*
- *Establishing monitoring programmes*
- *Preparing and Implementing NAP*
- *Report inventory of pollutants and authorizations*
- *Report the results of monitoring*
- *Report on NAP implementation effectiveness*

Main findings

1- It is important to note that a considerable number of Contracting Parties have reported the status of authorization per sector, quantity of releases per sector or quantities released per substances in accordance with the respective annexes of the LBS Protocol.

2- Several Contracting Parties provide information on trend, compliance and bio-monitoring, however not all of them report to MED POL the data generated by monitoring.

3- There are some countries that do not submit the data in accordance with the agreed format. The manual upload of such data to the respective regional data basis is impossible. The system has been designed in the Microsoft Access format with the use of the Microsoft Visual Basic programming language, which provides the platform to customize the software and to design a customer-based database. Further efforts should be made by some Contracting Parties to ensure a correct monitoring data submission.

4- Information with regard to NAP implementation is scarce for most of the Contracting Parties.

5- Only few Contracting Parties have provided information on enforcement and effectiveness indicators.

Recommendations:

- *Enhance/harmonize the relationship between NBB and the technical tables of the LBS protocol reporting requirements. There is a need to analyze and streamline them in terms of content and reporting frequency.*
- *Strengthen country capacities to submit on line the monitoring data*

4. Hazardous Waste Protocol

The Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal (Hazardous Wastes Protocol) was ratified by seven Contracting Parties and entered into force in 2008.

With regards to the technical aspects of its implementation, the seven parties to the Protocol are bound to report data on:

- *quantities of generated HW,*
- *quantities of import/export HW, their listing according to the agreed categories*
- *data on availability of options for alternative disposal of HW,*
- *data on enforcement and effectiveness indicators.*

Findings

1. The information provided with regard to the technical aspects of the implementation of the HW Protocol is scarce for most of the Contracting Parties that have submitted implementation reports.

2. It is important to note that a considerable number of countries have provided information with regard to measures taken to implement the regional plan on 20% reduction in 2011 of HW.

b) Up-to-date tools to control and assess pollution

As informed in document UNEP(DEPI)/MED WG. 379/3, (Progress report on the implementation of MED POL activities in the framework of MedPartnership project), work has advanced with regard to preparation of correlation model ELV/EQO and the establishment of a data base for riverine nutrient inputs presented in documents UNEP(DEPI)/MED WG. 379/Inf.6, and UNEP(DEPI)/MED WG. 379/Inf.7. These reports contain findings and recommendations that will be presented to the meeting for the consideration of the MED POL Focal Points.

II. Implementing the Regional Plans adopted in the framework of Article 15 of the LBS Protocol of the Barcelona Convention

The Fifteenth Meeting of the Contracting Parties adopted decision IG.17/8 on the implementation of the national action plans and the preparation of measures and implementation timetables, which were to become legally binding one year following the entry into force of the Protocol (article 15 of the Land-based Sources Protocol). Six such regional plans have been adopted under article 15.

The Sixteenth Meeting of the Contracting Parties, held in Marrakech in 2009, adopted three regional plans under article 15 of the Protocol (decisions IG.19/7 on urban wastewater; IG.19/8 on the elimination of a number of POPs and IG.19/9 on the phasing out of DDT). These three regional plans were notified by the Secretariat to the Contracting Parties on 18 December 2009. All three national plans were adopted as they stood by the Contracting Parties and entered into force on 16 June 2010, 180 days following the date of notification of 18 December 2009. The measures in question will come into force in 2015, and for Turkey in 2020 with regard to the regional plan on the reduction of biological oxygen demand (BOD) in municipal wastewater.

In 2012, three new regional plans (decisions IG.20/8.1 on reducing inputs of mercury; IG.20 /8.3 on the reduction of BOD_5 in the food sector and IG.20/8.3 on the elimination of 10 persistent organic pollutants) were adopted by the Seventeenth Meeting of the Contracting Parties, held in Paris in 2012, pursuant to this article. These three regional plans were notified to Contracting Parties on 11 April 2012. As none of the countries among the 17 Contracting Parties which are parties to the Protocol, expressed any reservations with regard to these three regional plans, they were adopted as they stood by the Seventeenth Conference of the Parties in February 2012 and entered into force 180 days after that date, pursuant to article 15 of the Land-based Sources Protocol, namely, on 8 October 2012. The information regarding the status of entry into force of the regional plans is presented in Annex I.

Regional Plan on reduction of Mercury inputs (Decision IG.20/8.1)

With the view to facilitate the implementation of and reporting on measures taken, a simple table (presented in this document as Annex II) specifying some specific reporting obligations for each provision/measures, where appropriate together with timetables was presented to the participants of the Almaden (Spain) Workshop held in December 2012. The table also lists various elements and indicators to be included in the report. The timetables for implementing different measures are 2013, 2015 and 2020.

Article 5 of this Regional Plan mandated the Secretariat to prepare guidelines on the decontamination of sites contaminated with mercury herein referred to as mercury decontamination guidelines. The draft guidelines were prepared by CP/RAC and MED POL and are submitted for review and approval as appropriate by the MED POL Focal Points meeting. The draft guidelines are presented in Annex IV of this document.

According to Article 4 of the Regional Plan, the status of measures is to be reviewed in 2015. In addition, a new global convention on mercury is expected to be opened for signature in

October this year. A first simple comparative analysis between the draft Global Convention on Mercury and the Mediterranean Mercury Regional Plan is presented as Annex III to this document for information purposes. In the Secretariat's view, it is important to ensure necessary synergies where appropriate with the forthcoming global convention while reviewing in 2015 the measures provided for in the Regional Plan following discussion and agreement by the MED POL focal points.

Regional plan on BOD from food sector (Decision IG.20/8.2)

With regards to the Regional Plan on BOD from food sector (Decision IG.20/8.2), the measures defined by article 4 of the Regional Plan involve bringing into play the best available techniques (BAT) and best environmental practices (BEP) with the aim of enabling the Parties to comply with the adopted ELV. The measures shall be implemented in 2014. The agreed ELV will be reviewed in 2015 on the basis of reports submitted by the Parties on the implementation of the regional plan, on any difficulties encountered in their implementation, and taking into account new developments in BAT and BEP in the region and the need to reduce the consumption of water. It is important to consider the preparation of a simple reporting format for this purpose that would allow the Contracting Parties to provide sufficient information that would allow the Secretariat to be in a position to propose in consultation with the MED POL FP revised measures where appropriate.

Regional Plans on POPs (Decision IG.20/8.3)

The measures provided for under article 3 of these regional plans are directed towards banning, eliminating or regulating the production, use, import and export of the 10 persistent organic pollutants (POPs) in full synergy with the obligations and the work under the Stockholm Convention. The decision states that these measures shall be implemented in 2013.

There are some differences between the Regional Plan and the Stockholm Convention which may also affect reporting:

- Lindane does not have specific exemptions in the Regional Plan as it is the case in the Stockholm Convention
- The recycling exemption for articles that may contain Hexabromodiphenyl ether, Heptabromodiphenyl ether,,Tetrabromodiphenyl ether and Pentabromodiphenyl ether ends in 2020 (2030 in the Stockholm Convention)
- Export of articles that contain levels/concentrations of Hexabromodiphenyl ether and Heptabromodiphenyl ether,exceeding those permitted for the sale, use, import or manufacture of those articles within territory of the party are prohibited (The Parties to the Stockholm Convention shall "take steps to prevent the exports")
- Endosulfan production is not allowed in any case.
- Reporting frequency is every two years. It also provides for adjustment with the Stockholm Convention according to which the reporting obligation is every four years
- The Regional Plan provides for a list of a series of BAT / BEP as a recommendation to the countries. The reporting format may have some questions related to the implementation of those measures.

Therefore it is important to establish close collaboration with Stockholm Convention and consider preparing a joint Reporting Format.

Regional Plan for Aldrin, Chlordane, Dieldrin, Endrin, Heptachlor, Mirex and Toxaphene (IG.19/8)

This regional Plan includes only the initial POPs pesticides. The Regional plan has slight differences with the text of the Stockholm Convention:

- The reporting frequency every two years whereas for the Stockholm Convention is every four years.
- The Regional Plan provides that the first deadline for reporting is 2011 (not complied with by any Party so far) and that countries shall identify stockpiles of pesticides before June 2010 (no report received so far).
- The regional plan specifies concrete Best Available Techniques for the elimination of these substances.

Therefore it is important to establish close collaboration with Stockholm Convention and consider preparing a joint Reporting Format or the Parties can submit the same report prepared for the purpose of the Stockholm Convention.

Annex I

Status of entry into force of the Regional Plans

Name of regional plan	COP decisions	Entry into force	Comments
Regional plan on the reduction of BOD in urban wastewater	COP 16 Marrakech 2009 decision IG.19/7	16 June 2010 (180 days following the date of notification, 18 December 2009)	All the Contracting Parties have endorsed the regional plan except Turkey, which requested postponement of the date on which these measures were to be applied pursuant to article 4 of the regional plan (2020, rather than 2015)
Regional plan for the elimination of certain chemicals	COP 16 Marrakech 2009 decision IG.19/8	16 June 2010 (180 days following the date of notification, 18 December 2009)	All the Contracting Parties have endorsed the regional plan
Regional plan on the phase-out of DDT	COP 16 Marrakech 2009 decision IG.19/9	16 June 2010 (180 days following the date of notification, 18 December 2009)	All the Contracting Parties have endorsed the regional plan
Regional plan on the reduction of inputs of mercury	COP 17 Paris 2012 decision IG.20/8.1	8 October 2012 (180 days following the date of notification, 11 April 2012)	All the Contracting Parties have endorsed the regional plan
Regional plan on the reduction of BOD produced by the agrifood industry	COP 17 Paris 2012 decision IG 20/8.2	8 October 2012 (180 days following the date of notification, 11 April 2012)	All the Contracting Parties have endorsed the regional plan
Regional plan on the elimination of 10 persistent organic pollutants	COP 17 – Paris 2012 decision IG 20/8.3	8 October 2012 (180 days following the date of notification, 11 April 2012)	All the Contracting Parties have endorsed the regional plan

Annex II

Regional plan on the reduction of inputs of mercury in the framework of the implementation of article 15 of the LBS Protocol

Reporting obligations and requirements

Geographical scope: LBS Protocol Area (Art 4)

	Measure(s)/obligations	**Targets to be achieved**	**Implementation timetable**	**Reporting requirements frequency**	**Suggested reporting elements and indicators**	**National Implementation reports**
1	Prohibit new chlor-alkali plants with Hg cells	No new plants	Immediate effect upon entry into force in Oct 2012	On biannual basis	-National Legal/regulatory acts in force or under preparation; -Enforcement actions -Other Measures taken, -Difficulties encountered -Effectiveness indicators	2013 and 2015
2	Prohibit vinyl chloride monomer plant installation using Hg as catalyst	No new plants	Immediate effect upon entry into force in Oct 2012			
3	Cease Hg releases from chlor alkali plants	No Hg releases from chlor- alkali plants	By 2020 at the latest		-National Legal/regulatory acts issued or under preparation -Action plans/roadmap for its implementation -Monitoring data in the framework of Medpol hot spot monitoring programme; -Inventories of releases in the framework of NBB/PRTR	
4	Achieve environmental sound management of mercury and mercury wastes from decommissioned plants	No quantified target	On plant decommission			
	Progressively reduce total Hg releases to air, water and products until their final cessation	<1,0 g per metric tone in each plant Air emission <0,9 g per metric tone in each plant (of installed capacity of the decommissioned Chlor alkali plants)	By 2015 (as the plants should be closed in 2020 at the latest)		-Legal/regulatory acts issued or under preparation -Technical measures: BAT and BEP put in place -Implementation Action plans/roadmap 2015 -Monitoring data in the framework of MED POL monitoring programme; -Inventories of releases in the framework of NBB/PRTR	
5	Prohibit Re-entry of Hg (into the national market or exported) from	No mercury available in the national market or	Immediate effect upon entry into		National Legal/regulatory acts issued or under preparation;	2013

	Measure(s)/obligations	**Targets to be achieved**		**Implementation timetable**	**Reporting requirements frequency**	**Suggested reporting elements and indicators**	**National Implementation reports**
	decommissioned plants	exported from decommissioned plants		force in Oct 2012		Decommissioning plan Destination of the decommissioned Hg Quantities and Disposal measures detailed	
6	a) Use of mercury catalysts in the manufacture of polyurethane elastomers	50 micrograms/liter	5[1]	By 2015	On biannual basis	Legal/regulatory acts issued or under preparation to ensure compliance with the 2015 target Inventory, location and capacity of the plants per country Technical measures: BAT and BEP put in place or envisaged to ensure compliance with the 2015 target as appropriate Any Action plans/roadmap or other tool to ensure as appropriate compliance with 2019 target	2013 and 2015
7	b) Acetaldehyde production with mercury-sulphate (HgSO4) as catalyst						
8	c) Vinyl acetate production with Hg catalysts						
9	d) Production of the cube (1-amino anthrachion) colours/pigments with Hg catalyst						
10	e) Use of mercury intermediates for production of other mercury compounds						
11	f) Use of mercury intermediates in the pharmaceutical / chemical industry						
12	g) Manufacture of mercury catalysts						
13	h) Manufacture of organic and non-organic mercury compounds						
To set National ELV in the Battery Industries							

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[1] By 2019 as target value (to be revised in 2015)

14	Manufacture of batteries containing mercury	50 micrograms/l	5[2]	By 2015		National Legal/regulatory acts issued or under preparation to ensure compliance with the 2015 target Inventory, location and capacity of the plants per country Technical measures: BAT and BEP put in place or envisaged to ensure compliance with the 2015 target as appropriate Any Action plans/roadmap or other tool to ensure as appropriate compliance with 2019 target	2013 and 2015
	Mesure(s)/obligations	**Targets to be achieved**		**Implementation timetable**	**Reporting requirement frequency**	**Suggested reporting elements**	**Implementation reports**
To set National ELV in the Non Ferrous industry							
15	a-Mercury recovery plants b-Extraction and refining of non-ferrous metals	50 micrograms/l	5[1]	By 2015	On biannual basis	National Legal/regulatory acts issued or under preparation to ensure compliance with 2015 target Inventory, location and capacity of the plants per country Technical measures: BAT and BEP put in place or envisaged to ensure compliance with 2015 target as appropriate Any Action plans/roadmap or other tool to ensure as appropriate compliance with 2019 target	2013 and 2015
To set National ELV for the Waste treatment							
16	Plants for the treatment of wastes	50 micrograms/l	5[1]	By 2015	On biannual	National Legal/regulatory acts issued or under preparation to ensure compliance with the 2015 target	2013 and 2015

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[2] By 2019 as target value (to be revised in 2015)

					basis	Inventory, location and capacity of the plants per country Technical measures: BAT and BEP put in place or envisaged to ensure compliance with the 2015 target as appropriate Any Action plans/roadmap or other tool to ensure as appropriate compliance with 2019 target	
To set National ELV for Incineration Plants							
17	Waste gas	0.05 mg/ Nm3		By 2019 at the latest	na	National Legal/regulatory acts issued or under preparation to ensure compliance with the target Inventory, location and capacity of the plants per country Technical measures: BAT and BEP put in place or envisaged to ensure compliance with the target as appropriate Any Action plans/roadmap or other tool to ensure as appropriate compliance with 2019 target	2013, 2015, 2017, 2019
In Other sectors							
18	Take the appropriate measures to reduce the inputs of Mercury emissions and **use alternatives** as appropriate	Mercury substitution initiatives put in place. Mercury reduction attained		By 2019 at the latest	na	National Legal/regulatory acts issued or under preparation to ensure compliance with the target Inventory, location and capacity of t **any plant generating mercury emissions or mercury containing waste or mercury in products**– per country Technical measures: BAT and BEP put in place or envisaged to ensure compliance with the target as appropriate Any Action plans/roadmap or other tool	2013, 2015, 2017, 2019

					to ensure as appropriate compliance with 2019 target Hg reduction data	
In Mercury containing waste						
19	Take the appropriate measures to isolate and contain the mercury containing wastes to avoid potential contamination of air, soil or water	To identify and assure ESM of any waste containing mercury	By 2019 at the latest	On biannual basis	National Legal/regulatory acts issued or under preparation to ensure compliance with the target Inventory, location and capacity of the plants **generating any waste with mercury content** per country Technical measures: BAT and BEP put in place or envisaged to ensure compliance with the target as appropriate Any Action plans/roadmap or other tool to ensure as appropriate compliance with 2019 target	2013.2015,2017 and 2019
In Contaminated sites						
20	1. Identify existing sites contaminated with mercury including at least the old mines and decommissioned Chlor alkali plants, 2. Submit the inventory for submission to the Secretariat	List of sites -old mines -chlor alkali plants - other	January 2013	n/a	List of sites, locations, surface area decontaminated, level of pollution, Hg concentration in air, water and soil where appropriate	2013
21	Undertake environmentally sound management measures such as safety works, use restrictions or decontamination, as appropriate	ESM fully implemented	2015	biannual	Concrete measures envisaged for each site; type of technology used, level of expected decontamination, decontamination timeframe	2013.2015
New mines						
22	Prohibit new mines or re-opening of old mercury mining sites	No new or reopened old Hg mines in the Mediterranean	With immediate effect upon entry into force	NA	National Legal/regulatory acts issued or in process of preparation	2013
Monitoring and enforcement						
23	Ensure that competent authorities or appropriate bodies monitor releases of Mercury into water, air and soil to	National monitoring plan in place including Hg	With immediate effect upon entry into force	Monitoring data annually.	Monitoring data submitted to the Secretariat on annual basis Releases data in accordance with	2013, 2015, 2017, 2019

	verify compliance with the requirements of the above table			Other reports on bi-annual basis	NBB/PRTR reporting cycle	
24	The Parties shall take the necessary steps to enforce the above measures	Enforcement measures in place, mercury releases reduced /phased out and eliminated	With immediate effect upon entry into force	On biannual basis	Enforcement measures such as inspectorate controls in accordance with LBS protocol effectiveness indicator	2013, 2015, 2017, 2019

ANNEX III - COMPARISON OF REGIONAL PLAN ON MERCURY vs. MINAMATA CONVENTION

	Potential discrepancy (Y/N)	article	REGIONAL PLAN ON MERCURY	Implementation timetable	Articles	MINAMATA CONVENTION	Implementation timetable
			Mines				
1	Y	4.6	No mention to existing mines	-	3.4	Each Party shall only allow primary mercury mining that was being conducted within its territory at the date of entry into force of the Convention for it for a period of up to fifteen years after that date. During this period, mercury from such mining shall only be used in manufacturing of mercury added products in accordance with Article 4, in manufacturing processes in accordance with Article 5, or be disposed in accordance with Article 11, using operations which do not lead to recovery, recycling, reclamation, direct re-use or alternative uses.	*date of entry into force of the convention 2018 +15*
			New Sources				
2	y		Not provided	-	5.6	Each Party shall not allow the use of mercury or mercury compounds in a facility that did not exist prior to the date of entry into force of the Convention for it using the manufacturing processes listed in Annex B (Chlor-alkali, Acetaldehyde production, VCM, Sodium or Potassium Methylate or Ethylate, production of polyurethane).	*date of entry into force of the convention 2018?*
3	Y (new industrial plants with mercury could be developed until 2018 or by Parties not ratifying the Convention)		Not provided (except for new Chlor alkali plants)	-	5.7	Each Party shall discourage the development of any facility using any other manufacturing process in which mercury or mercury compounds are intentionally used that did not exist prior to the date of entry into force of the Convention, except under requirement (see article)	*date of entry into force of the convention 2018?*
4			Not provided		8.4	For new sources of Annex D (Coal fired power plants, cement production, etc) each Party shall require BATs and BEPs	*date of entry into force of the convention*
			Non chlor-alkali plants				
5	y	4.B.A.b	Not provided (excep for ELV 50 ug/l for 2015 and 5? ug/l in 2019)	-	5.2	Phase-out of Acetaldehyde production with mercury catalyst	**2018**
6	y	4.B.A.a	Not provided (except for ELV 50 ug/l for 2015 and 5? ug/l in 2019))	-	5.3	Phase-out of Polyurethane production with mercury catalyst	*date of entry into force of the convention +10 2028?*
7	y	4.B.A.h	Not provided (except for ELV 50 ug/l for 2015 and 5? ug/l in 2019 for organic mercury compounds)	-	5.3	Phase-out of Sodium or Potassium Methylate or Ethylate	*date of entry into force of the convention*
8	y	4.A.2	Prohibition of new VCM Plants, but no mention to existing VCM plants	*oct-2012*	5.3	Measures to reduce use of Hg by 50% by the year 2020 against 2010 use in existing VCM plants and phase-out after 5 years that the COP decides that an alternative process is feasible.	*date of entry into force of the convention*

ANNEX III - COMPARISON OF REGIONAL PLAN ON MERCURY vs. MINAMATA CONVENTION

	Potential discrepancy (Y/N)	article	REGIONAL PLAN ON MERCURY	Implementation timetable	Articles	MINAMATA CONVENTION	Implementation timetable
9			measures to sources to the atmosphere (Coal fired power plants, Cement, etc) not provided (except waste incineration)		*Annex D article 8*	For existing sources a Party may prepare a National Plan setting out the measures to be taken to control emissions, after 4 years of the date of entry into force. List of point sources: -Coal fired power plants -Coal fired industrial boilers -Smelting and roasting processes of the production of non-ferrous metals. -Cement clinker production - Waste incineration facilities	*date of entry into force of the convention +4 2022?*
10		4.B.A, B,	provision only for ELVs		5.5	Each Party with one or more facilities that use mercury or mercury compounds in the manufacturing processes listed in Annex B shall: (a) Take measures to address emissions and releases of mercury or mercury compounds from those facilities; (b) Include in its reports submitted pursuant to Article 21 information on the measures taken pursuant to this paragraph; and (c) Endeavour to identify facilities within its territory that use mercury or mercury compounds for processes listed in Annex B and submit to the Secretariat, no later than 3 years after the date of entry into force of the Convention for it, information on the number and types of such facilities and the estimated annual amount of mercury or mercury compounds used in those facilities.	*Date of entry into force +3 2021?*
11		4.3	The Parties shall take the appropriate measures to reduce the inputs of Mercury emissions from other sectors and use alternatives as appropriate.	*not fixed*	8.5	For its existing sources, each Party shall include in any national plan, and shall implement, one or more of the following measures, taking into account its national circumstances, and the economic and technica l feasibility and affordability of the measures, as soon as practicable but no more than ten years after the date of entry into force of the Convention for it: (a) A quantified goal for controlling and, where feasible, reducing emissions from relevant sources; (b) Emission limit values for controlling and, where feasible, reducing emissions from relevant sources; (c) The use of best available techniques and best environmental practices to control emissions from relevant sources; (d) A multi-pollutant control strategy that would deliver co-benefits for control of mercury emissions; (e) Alternative measures to reduce emissions from relevant sources.	*Date of entry into force +10 2032?*
12		4.3	The Parties shall take the appropriate measures to reduce the inputs of Mercury emissions from other sectors and use alternatives as appropriate.	*not fixed*	8.4	For its new sources, each Party shall require the use of best available techniques and best environmental practices to control and, where feasible, reduce emissions, as soon as practicable but no later than five years after the date of entry into force of the Convention for that Party. A Party may use emission limit values that are consistent with the application of best available techniques.	*Date of entry into force +5 2023?*
			Chlor-alkali Plants				

ANNEX III - COMPARISON OF REGIONAL PLAN ON MERCURY vs. MINAMATA CONVENTION

	Potential discrepancy (Y/N)	article	REGIONAL PLAN ON MERCURY	Implementation timetable	Articles	MINAMATA CONVENTION	Implementation timetable
13		4.A.3	The parties shall ensure that the releases of mercury from the activity of Chlor alkali plants shall cease by 2020 at the latest and:	-	5.2	Each Party shall not allow, by taking appropriate measures, the use of mercury or mercury compounds in the manufacturing processes listed in Part I of Annex B after the phase-out date specified in that Annex for the individual processes, except where the Party has a registered exemption pursuant to Article 6.	*2025 (2035 upon request)*
14	Y(recovery, recycling, reclamation, direct re-use inside the company is not forbidden)	4.3.A.i	that the environmentally sound management of metallic mercury from the decommissioned plants is achieved, including the prohibition of its re-entry into the market.	*2012-2020*	3.5(b)	Take measures to ensure that, where the Party determines that excess mercury from the decommissioning of chlor-alkali facilities is available, such mercury is disposed of in accordance with the guidelines for environmentally sound management referred to in paragraph 3 (a) of Article 11, using operations that do not lead to recovery, recycling, reclamation, direct re-use or alternative uses.	*Date of entry into force 2018?*
15		4,A.3.ii	that the total releases of mercury (to the air, the water and to the products) from existing Chlor alkali plants are progressively reduced until their final cessation with the view not to exceed 1.0g per metric tonne of installed chlorine production capacity in each plant. In doing so, the air emissions should not exceed 0.9g per metric tonne of installed chlorine production capacity in each plant.	*2012-2020*	5.5(a)	Each Party with one or more facilities that use mercury or mercury compounds in the manufacturing processes listed in Annex B shall: (a) Take measures to address emissions and releases of mercury or mercury compounds from those facilities;	*Date of entry into force 2018?*
			National Plan & Implementation				
16		4.3	The Parties shall take the appropriate measures to reduce the inputs of Mercury emissions from other sectors and use alternatives as appropriate.	*not fixed*	8.3	A Party with relevant sources shall take measures to control emissions and may prepare a national plan setting out the measures to be taken to control emissions and its expected targets, goals and outcomes. Any plan shall be submitted to the Conference of the Parties within 4 years of the date of entry into force of the Convention for that Party. If a Party develops an implementation plan in accordance with Article 20, the Party may include in it the plan prepared pursuant to this paragraph	*Date of entry into force +4 2022?*
17			not provided		20.1	Each Party may, following an initial assessment, develop and execute an implementation plan, taking into account its domestic circumstances, for meeting the obligations under this Convention.	*Date of entry into force 2018?*
18			not provided		19.1	Assessments of the impact of mercury and mercury compounds on human health and the environment, in addition to social, economic and cultural impacts, particularly in respect of vulnerable populations	
			Inventories of use, consumption, emissions and releases				

ANNEX III - COMPARISON OF REGIONAL PLAN ON MERCURY vs. MINAMATA CONVENTION

	Potential discrepancy (Y/N)	article	REGIONAL PLAN ON MERCURY	Implementation timetable	Articles	MINAMATA CONVENTION	Implementation timetable
19			not provided		8.7	Each Party shall establish, as soon as practicable and no later than five years after the date of entry into force of the Convention for it, and maintain thereafter, an inventory of emissions from relevant sources.	*Date of entry into force +5 2023?*
20			Releases to land and water not contemplated (other than ELVs for some industries in article 4.B		9.3	Each Party shall, no later than three years after the date of entry into force of the Convention for it and on a regular basis thereafter, identify the relevant point source categories.	*Date of entry into force +3 2021?*
21			not provided		19.1	Parties shall endeavour to cooperate to develop and improve, taking into account their respective circumstances and capabilities: (a) Inventories of use, consumption, and anthropogenic emissions to air and releases to water and land of mercury and mercury compounds;	*Date of entry into force 2018?*
22			not provided		9.6	Each Party shall establish, as soon as practicable and no later than five years after the date of entry into force of the Convention for it, and maintain thereafter, an inventory of releases from relevant sources.	*Date of entry into force +5 2023?*
23			not provided		18.2	Each Party shall use existing mechanisms or give consideration to the development of mechanisms, such as pollutant release and transfer registers where applicable, for the collection and dissemination of information on estimates of its annual quantities of mercury and mercury compounds that are emitted, released or disposed of through human activities.	
			Dental amalgam				
24			Dental amalgam not mentioned		4.3	Each Party shall take measures for the mercury-added products listed in Part II of Annex A (Dental amalgam) in accordance with the provisions set out therein.	
			Storage				
25	Y (if a Party doesn't ratify the Convention)		not provided (except for mercury from decommissioned chlor-alkali plants)		10.2	Each Party shall take measures to ensure that the interim storage of such mercury and mercury compounds intended for a use allowed to a Party under this Convention is undertaken in an environmentally sound manner, taking into account any guidelines, and in accordance with any requirements, adopted pursuant to paragraph 3.	*Date of entry into force 2018?*
			Monitoring				
26			not provided		19.1	(b) Modelling and geographically representative monitoring of levels of mercury and mercury compounds in vulnerable populations and in environmental media, including biotic media such as fish, marine mammals, sea turtles and birds, as well as collaboration in the collection and exchange of relevant and appropriate samples;	*Date of entry into force 2018?*
			Information on Trade				

ANNEX III - COMPARISON OF REGIONAL PLAN ON MERCURY vs. MINAMATA CONVENTION

	Potential discrepancy (Y/N)	article	REGIONAL PLAN ON MERCURY	Implementation timetable	Articles	MINAMATA CONVENTION	Implementation timetable
27			not provided		19.1	(f) Information on commerce and trade in mercury and mercury compounds and mercury-added products	*Date of entry into force 2018?*

Annex IV

DRAFT GUIDELINES ON BEST ENVIRONMENTAL PRACTICES FOR THE SOUND MANAGEMENT OF MERCURY CONTAMINATED SITES

Foreword

These Guidelines have been commissioned MEDPOL and CP/RAC to the Spanish National Technological Center for Mercury Decontamination (CTNDM), which counts with a vast technological experience in mercury management and offers scientific and technological support to eliminate the hazards related to the presence of mercury in products, emissions and wastes.

The Guidelines have been prepared by Manuel Ramos, Javier Carrasco, Ana Conde and Engracia Delacasa, from the National Technological Centre for Mercury Decontamination (CTNDM) and from Minas de Almadén (MAYASA), and from collaborations of Marc Pujols and Gracia Ballesteros from ACUAMED; Antoni Malet and Antonio Caprino from SOLVAY IBÉRICA, and Josep Maria Chimenos from the University of Barcelona. The coordination and technical supervision was ensured by CP/RAC. Document UNEP(DEPI)/MED WG.379/Inf.17, is also prepared to support the implementation of these guidelines.

1. Introduction

In general, a **contaminated site** is a place where there is an accumulation of toxic substances or residues which affects the soil and/or groundwater and/or sediments to levels that pose a risk to the environment or human health and may be above the safe limits recommended for a specific use. Various activities have led historically to mercury-contaminated sites, generally as a result of lack of environmental regulations, use of pollutant technologies and poorly waste management practices. These activities mainly include: mercury mining and quarrying; the chlor-alkali industry; coal-fired power-plants; cement industry; production of pig iron, steel and non-ferrous metals; the waste sector; the production of chemical substances, pharmaceutical products and catalysers; batteries and fluorescent lights. Currently the most important source of emission of mercury in the Mediterranean region are coal-fired power plants[1].

Metallic mercury is a liquid at room temperature, the only metal with this property and also evaporates at room temperature. Mercury is one of the most problematic substances that may be found at contaminated sites. Due to its physical and chemical properties, once mercury has entered the environment, it remains there adopting different physical and chemical forms reaching all of the environmental compartments to a greater or lesser extent: air, soil, water, sediments and even the buildings used for the activity. Inorganic mercury can be transformed by bacteria into methylmercury in sediments and soils, at a rate depending of the chemical characteristics of the soil. Methylmercury is a highly toxic bioavailable form of organic mercury and cumulative throughout the food chain. Consumption of fish and shellfish poisoned by direct dumping of methylmercury in the wastewater from a chemical factory in the Minamata bay (Japan) during decades was the cause of one of the worst episodes of chemical pollution recorded in the past century.

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[1] Diagnosis of Mercury in the Mediterranean Countries. CP/RAC, 2010.

2. International Legislation

2.1. Minamata Convention on Mercury (to be opened for signature in Autumn 2013)

The Minamata Convention on Mercury provides for control and reductions across a range of products, processes and industries where mercury is used, released or emitted.

With regard to contaminated sites, the global Convention on mercury shall adopt guidance on managing contaminated sites, but does not pose an obligation on remediation of contaminated sites.

2.2. Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention)

2.2.1 **Common Measures**, adopted in the 5th Conference of the Parties (1987) of the Barcelona Convention.

- The maximum concentration of mercury in effluent before dilution in the Mediterranean Sea is 50 µg/l.
- New outlets for mercury-containing effluents in the Mediterranean Sea should be designed and constructed to prevent an increase of mercury concentration in the biota and sediments to above 50% of the background level in a 5 km radius from the discharge point.

2.2.2 **Regional Plan on the reduction of inputs of Mercury (2012**). In the framework of the implementation of article 15 of the Protocol of Land Based Sources of pollution, the Mediterranean Action Plan (MAP) of the Barcelona Convention adopted in 2012 a legally binding text in order to reduce Mercury pollution, by which the Parties should establish limits of emission (ELVs) to different industrial sectors and **identify and envisage measures for mercury polluted sites**, including at least old mines and chlor-alkali plants.

2.3. European Union Legislation

2.3.1. Surface water and Groundwater

2.3.1.1 **Council Directive 98/83/CE** of 3 November 1998, on the quality of water intended for human consumption. Sets a limit for Mercury of 1 microgram per litre.

2.3.1.2 **Directive 2006/118/EC** of 12 December 2006, on the protection of groundwater against pollution and deterioration.

- Indicates criteria for assessing good chemical status of groundwater.
- Set the threshold values of the analytical parameters.
- Mercury is included in the minimum list of pollutants or groups of pollutants and indicators of pollution that member states should establish.

2.3.2 Soils

2.3.2.1 **Council Directive 86/278/EEC** of 12 June 1986 on the protection of the environment, and in particular of the soil when sewage sludge is used in agriculture.

2.3.2.2 **Council Directive 91/156/EEC** of 18 March 1991 establishes the obligation to draw up inventories of contaminated sites.

2.3.2.3 The thematic strategy for soil protection, ***Communication COM[2006]231-final,*** includes concepts like:

- the establishment of a legal framework to protect and use the soil sustainably;
- the integration of protection policies;
- the identification of risk areas
- the inventory of contaminated land and facilities
- the restoration of degraded soils.

2.3.2.4 The implementation of the Strategy and ongoing activities since 2006 were presented in document **COM (2012) 46 final**.

2.3.2.5 **Directive 2010/75/EU** on Industrial Emissions (IPPC). The industrial activities dealing with hazardous substances will have to establish through a baseline report the state of soil and groundwater before the start of activities and after the cessation of the activities.

2.3.3 All media

2.3.3.1 **Regulation EC no.166/2006**, concerning the establishment of an European pollutant release and transfer Register (E-PRTR), setting as compulsory to inform on emissions to air, water and soil above given limits.

2.3.4 Health and safety at work

2.3.4.1 **Commission Directive 2009/161/EU** establishing a list of indicative occupational exposure limit values.

3. Identification of mercury-contaminated sites

Remediation of a contaminated site, and specifically a mercury-contaminated site, is a corrective measure to mitigate or eliminate the pollution.

The first step towards achieving this is to ***thoroughly examine the origin, extent, type and amount of existing contamination.***

Once these parameters have been defined, the next step is to determine ***how and to what extent human health is or may be affected.***

Finally, and ***only after*** having investigated the aforementioned aspects, *corrective measures should be proposed and adopted to remediate safely the environmental damage and limit or eliminate the risk* of the contamination to any environmental vector and to the human health.

3.1 Identification of a mercury-contaminated site

The potentially contaminated site should be identified, as should its boundaries and the environmental compartments that are affected.

A contaminated site must be described in detail before a sound management policy can be applied: data need to be gathered so that the problem can be precisely defined and the contaminant/s and the potential receptors of the toxic substance must be identified.

The information obtained will help in the decisions about which measures to implement to prevent affection to the environment or human health. In short, the information will help to define the advisability of remediation and the techniques used.

The extent of the descriptive study is directly proportional to the complexity of the problem at the site that is being assessed. However, descriptive studies should generally involve two stages:

3.2 Stage I: Preliminary report on the situation

The preliminary report should contain a theoretical model of the mercury-contaminated site that draws on all of the previously known information. Data on the following aspects will be gathered during this stage:

- ✓ The location, surface area, and details of the physiographic region of the site.
- ✓ Historical records of the site and the surrounding area (climatology, etc.).
- ✓ Past, current and future uses of the place.
- ✓ Analytical data from previous studies.
- ✓ A survey of the site and the nearby area.

One important tool that helps to identify, quantify and characterize the contamination is a list of the activities and processes that have taken place on the site associated with mercury use and the estimated amount of mercury-containing wastes.

Once these factors have been identified, stage II should be carried out. This stage involves the drafting of a more detailed additional report to assess the degree of mercury contamination.

3.3 Stage II: Additional report

This report will contain the information required to draw conclusions and determine **whether or not** a more in-depth analysis is needed.

It is advisable to carry out a preliminary site inspection to meet three specific objectives: **a) describe the site**, **b) examine the type of contamination produced** by the mercury and **c) define the mechanisms of mercury mobility and the points of exposure**.

If detailed studies of the site are required, the environmental characterization stage will be carried out (Chapter 5).

The three specific objectives are discussed in more detail below.

3.2.1 Description of the site

This should include generalities on the location of the site, climatology, hydrology, hydrogeology, the demography of the area (size and distance from the nearest population), and potential environmental affection.

The report should include at least the following data:

- **Location**. A complete description of the location of the site and access to it. Geographic information on the site. Potential movement of the material deposited there, the production processes carried out, the source of waste, amounts of waste, and dumping or ways of packaging waste, etc.

- **Form and structure of any facilities**. Geometric characteristics, the building system and sequence, an estimation of the volume of material, the boundaries of the site and the uses of the immediately adjacent area.

- **Climatology**. A complete description of the climate using all available data, the average seasonal temperature, the annual rainfall and its distribution, the maximum precipitation, the predominant wind direction and seasonal wind patterns.

- **Geology of the area**, to discover the geological formations and the rocks found at the site, along with their characteristics.

- **Edaphology and land uses**. A complete description of the kinds of soil at the site, along with the soil characteristics and the land uses: industrial, agricultural, livestock farming, forestry, crop types, etc.

- **Surface drainage network**. A description of the fluvial flow throughout the year, permanent or seasonal rivers.

- **Socioeconomic aspects**. The demography and economy of the area.

3.2.2 Type of contamination

Unless chemical analyses have been carried out, it is difficult to accurately determine which contaminants are present at a site. However, during a site visit, it is possible to define with sufficient clarity the type of mercury contamination that has taken place. To achieve this, it is essential to find out about the activities and processes carried out in the area of interest, through interviews with the local authorities and with the population of the surrounding area. Information that is gathered in this way must always be summarized and filtered, particularly if the polluting activity was halted a long time ago.

The site should be defined in as much detail as possible in relation to the geometric and physical characteristic of the structure or structures that could potentially produce the contamination.

3.2.3 Identify the mechanisms of mercury mobility and points of exposure

A description of the site and of the type of contamination will enable us to predict the mechanisms of mercury mobility and the environmental compartments that are affected, where applicable. A good selection of points of exposure is extremely important, as environmental sampling should be comprehensive.

During the first site visit, the specialist in charge of the study should also define the areas in which there is no evidence of contamination. These areas will be used to take reference samples, which will serve to ***establish the natural or background level of mercury in the study area.***

A preliminary precautionary decision can be made to limit access and uses of the potentially contaminated area if knowledge of points of exposure gained in this first visit leads to the conclusion that there may be an exposure risk for people or animals. **The relevant local authority must be informed of this decision.**

The advisability of the measure can be reviewed later when the results of the analyses are available.

4 Identification of environmental impacts

National environmental safety and protection criteria should be used as a reference to identify environmental impacts at the contaminated site.

If no specific regulations exist, the principle of prudence should be considered in the study of the mercury-contaminated site. In this case, applicable published data, recommendations and international guidelines should be used as a reference. The conclusions obtained in this way and the decision of the relevant authority/ies will enable future actions to be evaluated.

As mercury is mobile, environmental impacts should be assessed in the various environmental compartments to determine the following risks.

- Hydrological risk:
  - Alterations in natural surface drainage and contamination of river beds due to runoff and leachate from the contaminated site.
  - Changes in the courses of streams adjacent to the site due to the accumulation or piling up of material in the beds, which may cut off the natural flow.
- Atmospheric risks:
  - Resuspension or reemission of particles of dust from the mercury-contaminated site that are carried by the winds.
  - Regasification and release of mercury present in piled up or contaminated materials, due to seasonal changes in temperature.
- Changes in soils:
  - Occupancy by accumulation of materials.
  - Nearby soil affection by dispersion of materials from the contaminated site, the deposition of dust or the runoff of rainwater.
- Impact on vegetation and wildlife:
  - Affection of plant species from the area and movement of wildlife to adjacent habitats.
- Morphology and landscape:
  - Visual impact on the main basins in the natural landscape due to the effect of piling up of material, lack of vegetation or colour changes.

5 Environmental characterization of mercury-contaminated sites

The selection of the environmental compartments that should be sampled will depend on the characteristics of the contaminated site or location: each site is different, so criteria that apply to one might not be applicable to another. In some places, surface water and sediment should be sampled; in others soil sampling may be sufficient; and in yet others emissions should be measured and soil, surface water and groundwater should be sampled.

When mercury contamination is detected at a site, it should also be sought in the surrounding area. Sampling should be carried out both ‘inside’ and ‘outside’ the site, to assess the possibility that the contamination affects adjacent surroundings.

However, in all cases, it is essential to obtain a reference sample to determine the background levels of mercury. If the site is in a mining area, a great deal of caution must be taken in defining the **reference level**. The mineral deposits could extend beyond the limits of the mine, due to the continuation of the geological formation that contains the deposit. Thus, high metal content results could be obtained that are not strictly due to the mining activity. In these cases, special attention should be paid to soils and aquifers.

Sampling

Sampling and analyses are essential elements in the assessment of mercury-contaminated sites.

The tasks of sampling, analysis and monitoring should be carried out by qualified professionals, in accordance with a well-thought-out plan, using widely accepted methods. The same methods should be used throughout the programme.

In addition, rigorous quality assurance and control measures should be applied. Sampling and analysis errors or deviation from the standard operating procedures could produce data of no value or even data that are detrimental to the programme.

The methods available for sampling, analysis and monitoring vary widely, depending of the different physical and chemical forms of mercury that can be present in a contaminated site. The OECD series (http://www.oecd.org/chemicalsafety/testing/) contains information on good laboratory practice that should be used. In addition, the WHO and UNEP document *Guidance for Identifying Populations at Risk from Mercury Exposure* contains useful information to follow on general methodological aspects.

The media to be sampled to assess mercury contaminated can be liquids, solids and gases:

a) Liquids:

- Leachates from landfills and deposits.
- Liquid collected from spills.
- Water (surface water, groundwater from wells and springs, drinking water and industrial effluents).

- Biological material (blood, urine, hair; particularly when the health of employees is being monitored).

b) Solids:

- Products and compounds that consist of mercury, that contain mercury or are contaminated with it.
- Solids from industrial treatment or elimination processes or sources (airborne ash, deposited ash, sediments, other waste, etc.).
- Containers, equipment or other materials: pipes, vessels, contaminated fabric and clothes, contaminated material used in packaging and wrapping, etc
- Soil, sediments and organic matter.
- Rubble, walls, floors, etc., from industrial facilities.

c) Gases:

- Air.

Analyses

Analysis is defined as the extraction, purification, separation, identification, quantification and notification of mercury concentrations in the matrix of interest.

In order to obtain significant, acceptable results, the analytical laboratory should have the required infrastructure and proven experience with the matrix and type of mercury to be analyzed. One excellent way to verify the validity of results is the participation in an inter-laboratory comparison programme.

The following criteria must be met to obtain high quality results:

a) Specification of the analytical technique.
b) Maintenance of the analytical equipment.
c) Validation of all of the methods used (including the laboratory's own methods).
d) Training of laboratory staff.

In general, mercury analysis is carried out in specialized laboratories and several analytical methods can be used.

Methods to analyse the various matrices of mercury may assess the total mercury content or the speciation of mercury. Some have been defined by the International Organization for Standardization (ISO) and the European Committee for Standardization (CEN). Other national methods have been drawn up, such as those of the United States (EPA) or Japan.

The various steps in analytical determinations are as follows:

a) Extraction
b) Purification
c) Identification with suitable detectors, such as inductively coupled plasma, atomic absorption spectroscopy, compact instruments, etc.
d) Quantification and notification of data, as appropriate
e) Presentation of reports, according to the established quality procedure

In addition, procedures such as homogenization and acceptance criteria for handling and preparing samples in the laboratory should be established.

5.1 Characterization of surface water and groundwater

5.1.1 Surface water

The mercury content of surface water at the contaminated site and in the surrounding area should be studied, as water may act as a pathway for the dispersal of contamination by leaching from the site.

To determine the impact of the contaminated site on surface water, an analysis will be carried out upstream of the supposed mercury point source and downstream of all the possible points of exposure. This analysis should focus on points at which the water is used for human consumption, recreation, cleaning clothes, etc.

Unfiltered samples are generally used to analyse surface water. In addition, sampling must be carried out in ***all of the seasons***, that is, in periods of rain and drought.

Whenever a body of surface water is analysed, information should be gathered on the **sediments**. For this purpose, simple and surface samples (0-5 cm) should be taken at places upstream and downstream of the pollution point source.

In areas where contamination is found in water, it is important to know if the aquatic fauna is fished for food, in order to assess the possibility of fishing restrictions.

Once the drainage network has been defined in the additional report, a sampling campaign should be designed for liquids and solids (sediments). The aim is to assess:

1- the water quality in the area surrounding the site;
2- the sediment quality in stream beds in the area;
3- whether sediments are affected by contaminated material or by the contaminant itself carried by the water.

The following tasks should be carried out to design the sampling campaign:

- Inventory of surface water points.
- Field survey of all the types of water points.
- Selection of sampling points and the period (or periods) most suitable for carrying out the sampling, depending on the climate.
- Establishment of background mercury levels in the area. Sampling points should be selected upstream of the study area, to assess the levels of mercury present before the water reaches the polluted area.

Mercury levels in surface water that are above the limits established for water for human consumption (1 µg/l) should generally be sufficient to merit an in-depth analysis of the source. Such levels could be proof of contamination or due to natural enrichment.

5.1.2 Groundwater

Aquifers are one of the media that are most vulnerable to contamination in hazardous sites. Therefore, they should be monitored not only by means of man-made wells, but also through samples collected from springs and other natural underground water sources.

Hydrogeological studies should be carried out in the study area, and should include some of the following activities:

a) The design of a preliminary scheme for hydrogeological conditions in the area, including the creation of an inventory of water points (water catchment points and springs in the area).
b) Field survey of all the water points. The following data should be gathered: construction characteristics, extraction capacity, piezometric level and physicochemical characteristics of the water.
c) Selection of sampling points and the period or periods that are most suitable for carrying out the sampling, depending on the climate.

When required by the size and complexity of the situation, additional information may need to be gathered through the following activities:

d) Test drilling around the site through structures and formations of hydrogeological or hydrochemical interest. This will reveal changes in the piezometric level and enable the detection of vertical gradients.
e) Hydraulic characterization tests in areas not investigated by the test drilling, to determine the permeability of the main structures in the area through the different rocks.
f) Hydrochemical sampling along the test drill holes by clogging stretches to reveal the chemical characteristics of the underground flow at different depths of water upstream and downstream of the pollution point source.

Due to the natural variability in aquifers, they ***should be analysed at least three times a year*****,** depending on the local climate.

The following parameters should be measured in the water.

Parameters measured in situ:

- Temperature
- Conductivity (salinity)
- pH (acidity)
- Dissolved oxygen
- Eh (redox potential)

Concentrations of metals:
- Mercury

- Arsenic
- Barium
- Chromium
- Iron
- Nickel

In addition to these analytical determinations, other tests can be carried out according to the type of production process that generated the mercury deposit, and the expected composition of the pollution point source.

Likewise, other measures can be implemented to determine the presence of anions such as sulphates, nitrates, nitrites, carbonates and ammonium.

Mercury levels in aquifers can only be compared with reference values (for example, those of the US-EPA) when the ***analysed samples have not been filtered***. The analysis should also include samples from domestic taps, as the concentration of contaminant in taps could be different from the values found in a well or spring.

In all cases, mercury levels above the reference levels for human consumption (1 µg/l) should be analysed to determine their source.

Sediment samples will be treated as follows:

- Dried at room temperature.
- Sieved at 200 mesh size, ASTM (75 µm).
- Analysed to determine the presence of metals, such as mercury, chromium, iron, nickel, lead, zinc, etc.

It is difficult to define the acceptable concentration limit for mercury in sediments. Samples need to be taken at points in the environment at which it can be guaranteed that there is no contamination. However, these sampling points must have geological substrates with similar characteristics to those in the contaminated site. Under these conditions, **t*****he average concentration values at the reference points plus twice the standard deviation can be taken as a reference level or background.***

5.2 Soils

Soils in the area surrounding the site should be characterized on the basis of the data collected in the additional report on:

- Road infrastructure (entrances, paths, roads in general).
- Land uses (agriculture and livestock, residential, etc.).

Before the soil sampling campaign is designed, a site survey should be carried out to take into account various factors, including:

- Geomorphology of the site.
- Topographical and geological characteristics, land uses, identification of escarpments, slopes, steeply sloping hillsides, instability, etc.

- Accessibility of the site and sampling areas.
- Identification of areas of natural ground and areas formed by backfill due to the movement of deposited materials. This point is of particular interest in the sampling of urban areas, where it is important to determine whether soil has been removed or mixed up by urban development works.

On the basis of this information and data from the additional report, guidelines will be established for the sampling campaign. Contamination is mainly dispersed by wind, through resuspension and sedimentation of fine materials (generally the distribution is marked by the directions of the main winds in the area), and by surface water.

Taking into account the distribution of the winds and the surface water that runs through the site, a rhombus-shaped sampling grid should be established with sides measuring 50 by 50 metres. The grid should be symmetrical about the direction of the prevailing winds direction, as it is considered a priori that these winds will have the maximum concentration of suspended particles in the gradient of contamination. In addition to the aforementioned grid, a series of regularly spaced points should be sampled in a concentric pattern around the boundary of the contaminated site (at around 150 m from the source), to compare and assess the impact of non-prevailing winds on the movement of solid particles.

The soil samples should be taken at three levels: simple surface (0-5 cm), at a depth of 0.5 m, and from rock samples obtained in test drill holes, if applicable. The aim of sampling at the first two levels is to discover potential variance between surface and deep soils due to mercury enrichment caused by migration from soil and concentration in the contact surface with the bedrock. Deep soil samples can be taken at every other sampling point. The hydrogeological test drill holes can be used for sampling, which should be preferably of continuous recovery of core.

Sampling should be carried out during the cold period at sites that are frequently affected by snow, and during the rainy period at sites with high rainfall that are affected by floods or surface flows of water.

Surface soil sampling will be carried out by removing a thin layer of earth and then taking the sample with a clean spatula. The deep soil sample will be taken at the same point as the surface sample using appropriate sampling equipment (auger). Samples from mechanical boreholes can be taken from the core.

Each sample could weigh approximately one kilogram, of which a portion of around 100 ml will be taken for analysis. The rest of the sample will be kept referenced and storaged for further tests, if necessary.

The solid samples will be treated as follows:

- Dried at room temperature.
- Sieved at 200 mesh size, ASTM (75 µm).
- Analysed to determine the presence of metals, such as mercury, chromium, iron, nickel, lead and zinc.

As with the sediments, it is difficult to define the acceptable concentration limit for mercury in soil. Samples need to be taken at points in the environment at which it can be guaranteed that there is no contamination. However, these sampling points must have geological substrates with similar characteristics to those in the contaminated site. Under these conditions, the average concentration values at the reference points plus twice the standard deviation can be taken as a reference level.

5.3 Characterization of air and food

5.3.1 Air

Mercury levels in ambient air should be considered because of the high dispersion and ease of evaporation of this metal. As mentioned above, sampling points should take into account industrial activities within and outside the site, as well as meteorological conditions.

There may be many sources of mercury in ambient air. However, high levels naturally indicate that there is mercury in the area. The measurement of mercury concentration in air is a rapid way to confirm the presence of the metal. This is because contaminants are commonly dispersed in air, but do not remain in it. As a result, levels drop once the source of contamination has been removed or reduced.

In its *Air Quality Guidelines for Europe*, the World Health Organization (WHO) established a guideline value of 1000 nanograms/m^3 (1 microgram/m^3) as an annual average for mercury in ambient air.

The United States Environmental Protection Agency (EPA) selected a reference concentration of mercury of 300 ng/m^3 for exposure in residential areas.

European Directive 2009/161/EU establishes maximum occupational exposure (8 hours per day) at 20,000 ng/m^3.

Modelling can be carried out to identify the most likely pollution point sources (samples of ambient air should always be taken). Air samples can be collected in 24-hour periods according to a schedule that takes into account the meteorological conditions throughout the year.

A detailed record should be kept of the meteorological conditions and all the activities that were being carried out in the area at the time of each sampling.

5.3.2 Food

The mercury content should be determined in plant and animal samples of the food produced in the area and other food that is frequently consumed by the population. Food generated by fishing and hunting should be included, as well as those from agricultural sources.
When sediments are contaminated, sampling should include species that are bottom feeders in rivers, streams and lakes. It is not as important to include fish that feeds in the water column.

According to the principle of precaution, the intake levels described in World Health Organization (WHO) recommendations should not be surpassed. In 2008, WHO published a guidance document http://www.who.int/foodsafety/publications/chem/mercury/en. to provide information on the potential impact of mercury exposure and to help, as much as possible, to identify at-risk populations.

In the guidance document, WHO indicates that two groups are particularly vulnerable to the effects of mercury. Foetuses are particularly sensitive to the effects of mercury. Intrauterine exposure to methyl mercury due to maternal consumption of fish (especially Tuna, Swordfish, Shark..) or seafood may damage a baby's brain and nervous system. The main consequence of methyl mercury is potential disorders of neurological development. As a result, exposure to this substance during the foetal stage may affect a child's cognitive ability, memory, concentration ability, language, fine motor skills and spatial and visual skills. Therefore, particular attention should be paid to pregnant women, breastfeeding women and women of childbearing age.

The second group is that of people who are systematically exposed (chronic exposure) to high levels of mercury. This group includes people with fish as staple food (subsistence fishing) or those individuals occupationally exposed.

As the population's eating habits could mean that their mercury intake approaches the limits, it is advisable to restrict access to affected foods and even to regulate the use of the land and/or the types of crops that can be grown in the affected area, to ensure that the health of the surrounding population is protected.

6. Risk assessment

Data derived from the environmental characterization of the site can be used for a process of risk assessment.

Risk assessment is a process that assigns magnitudes and probabilities to the adverse effects of contamination. Consequently, it is an instrument that can help to define whether or not environmental measures should be implemented at a contaminated site. Risk assessment can establish whether the degree of contamination present at a site will have harmful effects. The greater the risk of the contamination affecting living beings, the greater is the need to implement restoration programmes.

Risk assessment can be used to define remediation objectives for a site, which may be to reach (a) the maximum acceptable limits established by current legislation or by the relevant authority or (b) specific limits set for the site on the basis of the assessment.

Environmental risk assessment (**ERA**) estimates the probabilities of the occurrence of adverse effects on living beings (human and other) as a result of exposure to a contaminant. Firstly, ERA can establish whether or not the concentrations found at a site could have harmful effects. This information is then used to determine the extent of the required clean-up operation.

At this point, all of the data serve to answer this question: **Does the site represent a real or potential risk to the human population and/or to the biota?** If so, the following should be assessed:

- What is the magnitude of the risk?
- Should the site be restored to reduce the risk?
- If the site is not restored, could the risk increase and/or spread?

Once these questions have been answered, ERA constitutes a tool for deciding whether to carry out corrective actions at the contaminated site and for setting the final remediation objective.

The ideal objective is to restore the site and its uses with concentrations to the levels found in the environment prior to contamination through techniques described in point 7.1.1. However, this may be economically unfeasible and other options should be considered, as it is mentioned in that point.

The establishment of a target clean-up level **on the basis of a risk assessment** means that the contamination will be reduced to its maximum accepted level, which may be not necessarily zero. Thus, at the end point, the residual concentration of the contaminant will not constitute a risk to the human population and biota.

Risk assessment can be carried out in four clearly defined stages with specific objectives:

1. Identification and characterization of what is at risk. All analyses of these characteristics should help to assess the risk to human health and to ecosystems.

2. Analysis of the hazard level and toxicity. The aim of this stage is to identify elements or compounds that may be critical; to characterize the kind of effects they may have; and to evaluate dose-effect relationships, in order to predict the response to the contaminant for

a wide range of doses. This analysis is based on contaminant data and characteristics, referring to its environmental and toxicological behaviour.

3. Analysis of exposure. The aim is to estimate the rate of contact with the identified contaminants. The analysis is based on a description of exposure scenarios, as well as characterization of the nature and extent of the contamination.

4. Analysis of risks. The results of the previous stages are combined to objectively estimate the likelihood of adverse effects on the protected elements under the specific conditions of the site.

Other contaminants besides mercury may have an impact. Therefore, if there is evidence that other contaminants are present at the site, the responsible of the process must take the decision to include them in the study and assessment.

6.1. Characterization of toxicological effects

This section of the risk assessment evaluates and describes the effects of the significant contaminant (mercury) on the receptors identified through the different exposure routes.

Contamination receptors that are frequently at risk in mercury-contaminated sites are:

6.1.1. Humans

In humans and some animals, the potential effects and symptoms of mercury intoxication vary according to the chemical form of mercury, the exposure route (inhalation or ingestion) and the exposure dose, including the exposure time and the concentration of the mercury.

For all the inhabitants of an area where a mercury-contaminated site is located, the main potential exposure routes are as follows:

- breathing (absorption by inhalation) of elemental mercury

The absorption of metals in the gas or vapour phase is unusual, except in the case of mercury.

- eating (absorption by ingestion)

It is considered that mercury ingested in food is mainly in the form of methylmercury (an organic compound of mercury).

6.1.2 Terrestrial animals

In general, the symptoms of intoxication reported in animals for cases of mercury poisoning are not specific and depend on the exposure route, as in humans.

6.1.3 Aquatic biota

Many factors influence the potential toxicity of mercury in aquatic biota. These include the form of mercury, the developmental stage of affected organisms, and the chemistry of the water.

Changes in temperature, salinity and the hardness of the water also alter the toxicity of mercury to the biota.

It is widely accepted that the most toxic form of mercury is **methylmercury**. Reducing conditions (i.e. low-oxygen concentration) are needed for methylation to occur. These conditions mainly occur in the water-sediment interface and in the first few centimetres of bottom sediments. It is well known that bacterial action promotes methylation, which is the main process responsible for the transformation of inorganic mercury to an organic formulation able to enter throughout the food chain.

In aquatic systems, fish are the main receptors of mercury through ingestion, as they are exposed to mercury both in water and through the ingestion of plants and macroinvertebrates.

Fish and macroinvertebrates like shellfish can also absorb mercury through the gills.

Macroinvertebrates may also be exposed to mercury in sediments, as are species of fish that feed on material deposited on top of the sediments. Due to their position at the top of the food chain in aquatic systems, it is assumed that fish have the highest concentration of mercury of all kinds of aquatic biota.

6.1.4 Plants

Plants are generally not sensitive to inorganic forms of mercury (i.e. elemental mercury and ionic mercury), probably due to the high level of absorption of the metal by soil particles. This largely prevents the absorption of mercury and toxicity in plants, which normally do not concentrate heavy metals[2], but show greater access to organic forms of mercury, such as methylmercury, than to inorganic forms.

6.2 Evaluation of exposure

By this stage, we know the exposure routes, the receptors, the concentrations and the toxicity.
The evaluation of exposure consists in combining the results of the risk assessments for humans and ecosystems with dispersion studies to assess the degree of mobility of contaminants and to analyse concentrations in the different media that are affected.

The exposure sources that should be considered at a mercury-contaminated site are the media analysed in the environmental characterization (Section 5):

- Particles in suspension (PS)
- Gas emissions

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[2] Preventive Measures against Environmental Mercury Pollution and its Health Effects. Japan Public Health Association, 2002.

- Surface water
- Groundwater
- Soil
- Sediments

6.3 Risk characterization

Risk characterization is the final stage in the risk assessment. During this stage, the probability of the occurrence of adverse effects due to mercury exposure is evaluated, and the bases are established for future actions.

In addition, data and conclusions from the stages in which the toxicological characteristics and the effects of the significant contaminant were reviewed are analysed together, along with the evaluation of exposure. All of these data are combined with the reasoning behind the proposed conceptual model.

For human health, the contaminant dose received by an individual (calculated on the basis of the characterization of the exposure scenario) is compared with the toxicological reference values set for this substance and population strata.

The following results should be obtained:

a. Conclusions on the actual risk of contamination at the site for human and ecosystem receptors, as well as the risk of dispersion (future risk).

b. Estimation of the level of uncertainty in the risk analysis, in order to accurately evaluate the conclusions of the characterization.

This stage can be carried out with the help of validated software to simplify the calculations, taking into account that its suitability should be justified for the specific characteristics and conditions of the site. Otherwise another method of calculation should be used. If software is used, screenshots of the process should be provided to confirm the values that were entered and the conclusions obtained.

Some examples of commercial software applications[3] are:

-Risk-based corrective action (RBCA)
-Probabilistic risk assessment (PRA)
-Biotechnology-based direct toxicity assessment

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[3] Mention of trade names or commercial products does not constitute necessarily endorsement or recommendation of use.

7. Remediation of mercury-contaminated sites

7.1. Definition of corrective tasks: restrictions of use, isolation, decontamination, stabilization and others

One or more remediation technologies can be considered, taking into account the results of the site study, the target clean-up levels, the capacity of the available remediation technologies, and the intended future use of the site.

Remediation measures for mercury-contaminated sites depend on various factors associated with the location itself and with the potential impact on the environment and health. The main factors that influence the selection of an initial set of treatment technologies are:

a) The amount of mercury released during the operations.

b) The pollution point source.

c) The chemical states of mercury at the contaminated site.

d) The number, size and location of sensitive areas that are contaminated by mercury - that need to be cleaned up - .

e) In the case of mining operations, it is important to know precisely the geological formations that led to mercury extraction, in order to not to include them as polluted soil due to the mining activities.

f) The possibility of mercury methylation.

g) The possibility of leaching of mercury from soil or sediments.

h) Background mercury contamination, regional atmospheric deposition of mercury that is not associated with local sources.

i) The mobility of mercury in the hydrological system.

j) The local/national clean-up regulations for water, soils/sediments and air.

k) Receptors (surface water and / or groundwater, soil, air, biota, human..).

l) Bioavailability to the aquatic biota, invertebrates and edible plants.

m) Mercury concentrations in human, animal and plant receptors, which indicate exposure levels.

Once these factors have been evaluated, a more comprehensive analysis of the appropriate remediation techniques can begin.

Depending on the gravity, magnitude, degree and type of contamination by mercury and other pollutants and on the receptors, the recovery plan is likely to involve various remediation techniques or measures to reduce or contain the amount or toxicity of the contamination as effectively and efficiently as possible.

7.1.1 Information on mercury remediation techniques

Below, some of the treatment options for mercury-contaminated media are described. These techniques can be used in the remediation of a contaminated site.
In general, the aim of the techniques listed below is to recover the area by removing the mercury. The alternative is to restrict use of the contaminated area and limit access to it, at least until work can be started on recovery of the site.
Alternatively, a site can be contained by making it impermeable using natural materials such as clays or geosynthetic materials such as high density polythene sheets to prevent the evaporation and leaching of mercury. In addition, waste can be transported for storage in existing safe deposits or landfills that are built for this purpose. Another option is to propose different treatments for each area or product in a mercury-contaminated area.

7.1.1.1 Treatment of mercury-contaminated effluents (Source EPA 1997)

Numerous techniques can be used to treat mercury-contaminated effluents. Some processes are merely physical (sedimentation), others are physicochemical (coagulation-flocculation, adsorption, etc.), yet others are chemical (oxidation-reduction, precipitation, etc.).
The appropriate choice depends on various factors, mainly the speciation of the element and the presence of other agents.

a) Precipitation

Precipitation of mercury in the form of insoluble salts is one of the most common practices in effluent treatment.

The main precipitant is sulphide. Mercury sulphide is one of the most insoluble salts and is the form in which most of the mercury on the earth's crust is found (cinnabar).

The optimum pH for the reaction is 7. The precipitate that is formed is then subjected to a sedimentation process, which can be assisted by the addition of flocculants. Mercury concentration values after sulphide precipitation are between 10 and 100 µg/litre.

This process has some disadvantages, such as the formation of high volumes of sludge that require subsequent treatment, and the formation of soluble species due to an excess of sulphide. Therefore, it is not the most suitable treatment for mercury-contaminated effluents.

b) Adsorption

Treatments involving adsorption produce lower mercury concentration levels than those obtained by precipitation. As the concentration of the adsorbent increases, the levels of remaining mercury decrease. Other factors that affect this process are pH and mercury speciation.

The most commonly used adsorbent is activated carbon. This is generally in the form of granular activated carbon, in which the carbon has a relatively large particle size and can be used to fill columns.

c) Ion exchange

This is one of the main treatments for mercury-containing effluents. A wide range of resins can capture the different species of mercury. The technology is primarily designed to bind ionic mercury. It is not highly effective for organomercury compounds or elemental mercury.

The process is carried out in columns or tanks filled with the corresponding resin and equipped with systems for intake and outlet of the effluent, as well as clean water for rinsing, and regenerating solution.

Ion exchange systems have several advantages: they operate as needed, they are relatively insensitive to variability in effluent, they can produce zero concentration values, and a wide range of resins is available. The disadvantages include sudden exhaustion of the capacity, which means that the process must be monitored continuously, generation of a saline water effluent containing mercury, which must be treated, and potential problems when the process is used with water that contains a high level of total dissolved solids.

d) Oxidation – reduction

In some cases, oxidation and reduction processes are used to change the oxidation state of the mercury and thus promote its dissolution or decantation.

Oxidation is used in effluents that contain metallic mercury or organometallic compounds to transform them into the ionic form or to dissolve them as mercury halide. The process can take place in batch or plug flow reactors. Mercury salts separate from the matrix of waste materials and are then sent for further treatment, for example acid extraction or precipitation.

The most common oxidants are: sodium hypochlorite, ozone, hydrogen peroxide, chlorine dioxide and chlorine gas.

Reduction is used as a method for removing mercury in solution in the form of metallic mercury and then to sediment, filter or centrifuge it, for example. The most common reducing agents are: aluminium, iron, zinc, hydrazine, stannous chloride and sodium borohydride.

The decontamination rate is high in reduction processes when the mercury concentration is relatively high (up to 2 g/l). However, the efficacy of the process drops when the levels of mercury are low. In this case, further treatment is required.

e) Others

Other methods for treating mercury-contaminated effluents have given good results. However, many of these are still in the experimental stage.

Examples are: membrane separation (such as ultrafiltration and reverse osmosis), biological treatments (microorganisms that can absorb mercury or reduce it), liquid emulsion membrane extraction and solar photocatalysis with titanium dioxide, among others.

7.1.1.2 Treatment of mercury-contaminated solid waste (Source: EPA 2007)

Mercury-contaminated solid waste treatments have been classified into four categories:

a) Thermal treatments (retorting or roasting, among others)

b) Solidification/Stabilization (including amalgamation)

c) Vitrification

d) Washing/Acid extraction

a. Thermal treatments

Thermal desorption and retorting are two common methods for full-scale thermal treatment of mercury-contaminated waste and for the treatment of soils and sediments.

These treatments volatilize the mercury by low-pressure heat transfer, followed by condensation on a cold surface.

Elemental mercury that is collected in this way can be reused in processes or stored. Off-gases should be treated to avoid emissions of mercury or other components.

a.1 Retorting/roasting (Source: ITRC 1998)

Pre-treated waste is sent to a desorber or retort where it is heated at low pressure to volatilize the mercury. Heating may be direct through contact with combustion gases or indirect through a metal wall (e.g. electrical heating).

When desorbers are in operation, the waste inside them is agitated continuously. The movement increases heat and mass transfer, leading to higher evaporation rates. In contrast, waste in retort and roasting equipment is static.

The most common desorbers are directly heated rotary kilns and indirectly heated screw systems.

Direct heating systems require high volumes of combustion gases when a large volume of waste is treated. Consequently, complex control systems are required, and gas emissions must be treated. In these cases, the investment and operating costs could be much higher than in an indirectly heated system, in which combustion gas is not mixed with the hazardous waste.

a.2 Gas treatment

Gases from the retort system are filtered through fabric filters to remove particulate matter. Subsequently, the gas is cooled in a condenser to transform gaseous mercury into a liquid. The gas is then treated in control systems comprised of activated carbon filters and catalytic oxidants to capture any leakage of mercury vapour and organic volatile matter.

b. Solidification/Stabilization

Solidification and stabilization are physicochemical processes that tend to reduce the mobility of mercury to a certain extent by physically enclosing it (solidification) or forming chemical bonds with it (stabilization). Amalgamation, that is, the formation of a solid or semi-solid alloy of mercury with other metals, is a form of solidification.

There are two main solidification processes:

- Macroencapsulation: the encasing material is poured over and around the waste mass.
- Microencapsulation: the waste is mixed with the encasing material before solidification occurs.

b.1 Stabilization by sulphur

This process consists of converting liquid mercury into mercury sulphide (HgS); a form that is the most insoluble and common in nature.

There are two crystalline forms of mercury sulphide: alpha HgS and beta HgS, both of which are practically insoluble and have a very similar solubility in water.

If waste contains elemental mercury, Hg is mixed with S at room temperature and agitated rapidly. The energy produced by mixing is sufficient to cause the activation. Alternatively, a reaction can be carried out between Hg vapour and S inside a mixer with an inert atmosphere, to prevent the formation of HgO.

Oxidation of mercury to HgO should be avoided, as this species is more soluble than the sulphur. Therefore, it is advisable to work in an inert atmosphere and to add antioxidants (Na_2S).

b.2 Sulphur–polymer stabilization

This is a modification of the sulphur process. It consists in stabilizing the mercury through a reaction with sulphur, followed by solidification/microencapsulation in a polymer matrix.
It is carried out in two steps:

1. Stabilization: Reaction between elemental mercury and sulphur polymer cement (SPC, a mix of 95% sulphur and 5% polycyclopentadiene).
2. Solidification (and microencapsulation): Heating to 135°C.

There are several advantages to this process: the product that is obtained is monolithic and has a low specific surface area. Hence it is less volatile and leaching is less likely.

b.3 Amalgamation

This process consists in the formation of a mercury alloy with other metals (amalgam). As the concentration of metal increases, the amalgam becomes more solid. The metals that are most frequently used are: copper, selenium, nickel, zinc and tin.

To accelerate the process, finely divided metals are added to the mercury.

b.4 Other stabilizing agents – solidifying agents

Other substances that are used as a medium in these processes are: cement, calcium polysulfide, chemically bonded ceramic phosphate, phosphates, platinum and polyester resins, among others.

Of the various matrices used in solidification processes, we can distinguish between those that require previous stabilization and those that do not. The distinction is based on the strength of the material, to ensure that mercury is not released.

Table. Applicability of Mercury Treatment Technologies[a]

Technology	**Soil**[b]	**Waste**[c]	**Water**	
			Groundwater and Surface Water[d]	**Wastewater**[e]
Solidification/Stabilization	■	■		
Soil Washing and Acid Extraction	■	■		
Thermal Treatment	■	■		
Vitrification	■	■		
Precipitation/Coprecipitation			■	■
Adsorption			■	■
Membrane Filtration				■
Biological Treatment				■

Source: Sections 3.0 to 10.0 of the report *Treatment Technologies for Mercury in Soil, Waste, and Water* (U.S. Environmental Protection Agency. Office of Superfund Remediation and Technology Innovation. Washington [2007], DC 20460).
Notes:
■ Indicates treatment has been conducted at full or pilot scale.
[a] Media indicated here only if project-specific data are available. Some technologies may be applicable to more than one type of media.
[b] Soil includes soil, debris, sludge, sediments, and other solid-phase environmental media.
[c] Waste includes non-hazardous and hazardous solid waste generated by industry.
[d] Groundwater and surface water also includes mine drainage.
[e] Wastewater includes non-hazardous and hazardous industrial wastewater and leachate.

7.2 Safety measures. Prevention of occupational risks during clean-up work

Remediation tasks may lead to mercury exposure and all the risks that this entails, in addition to all the usual risks associated with the activity itself. To avoid risks, it is essential to know the mercury levels that workers are exposed to.

Environmental monitoring of the concentration of a toxin in air is the main instrument in the prevention of health-related occupational risks in general, and in relation to mercury in particular. There are two forms of environmental monitoring. **The first** involves sampling the air in a work area. **The second** focuses on staff and involves sampling the level of exposure of workers during their working day, as staff normally moves from one place to another during the day.

Another control for each exposed worker individually is the biological monitoring. This occupational health procedure measures a potential toxin, in this case mercury, its metabolites or an unwanted chemical effect in a biological sample, in order to assess individual exposure.

These measurements are known as biological exposure indicators or biomarkers. Biological monitoring measures the amount of the agent that has been absorbed, regardless of the pathway. It takes into account the elimination pathways, the toxicokinetics and the toxicodynamics of the corresponding substance. As a preventative measure, biological monitoring should be carried out regularly and repeatedly, but should not be confused with procedures for diagnosing occupational illness.

The daily environmental exposure limit values for mercury and for divalent inorganic compounds of mercury, including mercury oxide and mercury chloride (measured in mercury), is 0.02 mg/m^3, measured or calculated for a reference period of 8 h. These values are in accordance with Commission Directive 2009/161/EU establishing a third list of indicative occupational exposure limit values.

There are several procedures for the environmental determination of mercury. Both active and passive systems can be used. The choice of system will depend on the type of evaluation that is required, the instrumental conditions and the available techniques, as well as on the form of the contaminant. Devices for taking direct readings can be used to measure a specific concentration.

The most common method involves trapping mercury as a vapour. This is usually achieved through the use of adsorbent tubes (hopcalite, manganese bioxide and activated carbon, among others) or passive monitors (for example, gold and silver plates) that amalgamate the mercury. When mercury is trapped in adsorbent tubes, the amount is usually determined using atomic absorption spectrophotometry. If passive monitors have been used, variations in electrical conductivity are generally measured. If the mercury is in the form of particulate matter (powder), it is trapped in filters and analysed by Atomic Absorption spectrophotometry. Electrochemical techniques, such as polarography and stripping potentiometry, can also be used for the analytical determination.

Biological indicators can be established for elemental mercury and inorganic compounds. These are appropriate parameters in biological media from a worker (urine and blood), and can be measured at a specific time.

The biological limit value for total inorganic mercury in urine can be set at 35 µg/g of creatine before the working day, i.e. after 16 hours without exposure. The limit value for total inorganic mercury in blood can be set at 15 µg/l at the end of the working week, that is, after 4 or 5 consecutive days of exposure at work. These values correspond with the Occupational Exposure Limits for Chemical Agents in Spain (National Institute of Safety and Hygiene at Work, 2012).

Preventative measures can reduce workers' levels of exposure. These include ventilation systems that increase air renewal in working spaces. Clean air is brought into the work area and contaminated air is extracted to treat it in activated carbon filters. In addition, protective clothing can be worn, such as mouth and nose masks with Hg P3 filters, in accordance with European Respiratory Protection Standards (EN 141: 2000).

7.3 Environmental monitoring required during remediation work

Environmental remediation projects for mercury-contaminated sites should include an Environmental Monitoring Plan (EMP) in addition to the remediation activities themselves.

The aim of the EMP is to determine and assess the environmental impact or damage to the area around the contaminated site to be remediated, in all stages of the remediation work. Thus, the EMP will describe appropriate measures for mitigating or avoiding negative environmental effects of the remediation activity. Measures will apply to the design and location of the remediation activity, the remediation procedures, purification, and general mechanisms for protecting the environment.

The EMP for remediation activities at a mercury-contaminated site will define monitoring and measurement activities. Measurements will be divided into two groups:

1. Those made during implementation of the remediation work.
2. Those made after the remediation work or monitoring activities.

In these two groups, there will be a particular focus on:

- Surface water and groundwater quality.
- Particle and gas emissions that affect the quality of life of inhabitants of the area.

In addition, remediation activities will be monitored by means of topographic control and a photographic record. Meteorological data will also be gathered.

The EMP will establish the method for monitoring remediation actions: the kind of reports that are required, the content of the reports, their frequency, and when they will be issued in the framework of the remediation project.

Quality control of the remediation work and of the significant environmental aspects that were identified for the project (in the design, implementation and maintenance stages) will be carried out according to the guidelines established in the Environmental Monitoring Plan.

The following table shows some of the main aspects to include in an EMP for a remediation project at a mercury-contaminated site, during implementation of remediation work.

ENVIRONMENTAL MONITORING PLAN FOR A REMEDIATION PROJECT IN A MERCURY-CONTAMINATED SITE			
MEDIUM MONITORED	SAMPLING FREQUENCY	LOCATION	PARAMETERS
Surface water	Monthly	Water upstream of the immediate surroundings of the site to be remediated	Temperature pH Conductivity Dissolved oxygen Oxide-reduction potential (Eh) Nitrites COD Ammonia Mercury and other heavy metals
		Water downstream of the immediate surroundings of the site to be remediated	
	Quarterly	Water upstream of the area near the site to be remediated	Mercury and other heavy metals
		Water downstream of the area near the site to be remediated	Mercury and other heavy metals
	Six-monthly	Water upstream of an area further from the site to be remediated	Temperature pH Conductivity and mercury
		Water downstream of an area further from the site to be remediated	
Groundwater	Monthly	Drilling around the site	Mercury
	Six-monthly		

7.4 Monitoring and control of the expected results and of implemented activities

Once the option of remediation has been selected, a monitoring plan should be designed, implemented and run. This plan will determine the times and places at which monitoring will be carried out to assess the progress of the remediation actions and confirm that the targets have been met and that the site is not a risk to human health or the environment.

The design and implementation of a monitoring plan (MP) is highly specific to the type of remediation carried out and the contaminated site. Monitoring should be accompanied by assessment of the indicators, to verify whether or not progress has been made in the various activities that form part of the system or project under evaluation.

The aim of the basic control and monitoring indicators should be to verify that:

- Processes within the contaminated site that has been remediated are carried out according to plan.
- The environmental protection systems work exactly as proposed in the remediation project.
- There is compliance with the conditions of authorized use of the contaminated site.

At least the two following indicators should be evaluated during the period established by the relevant authority:

1. Meteorological data. It is essential to establish the meteorological data that will be collected from the site:

    - Volume of precipitation (daily and monthly values)
    - Minimum and maximum temperature (monthly average)
    - Direction and strength of the prevailing wind
    - Evaporation (daily and monthly values)
    - Atmospheric humidity (monthly average)

2. Emission data:

    - Monitoring of surface water at representative points. The monitoring of surface water **should be carried out at two or more points**, including water upstream of the site and water downstream of the site.

      Samples will be taken in different seasons, preferably every six months. The parameters will vary according to the characteristics of the site to be remediated. In the case of mercury contamination, the parameters should include the concentration of mercury and of other heavy metals, anions, pH, conductivity, etc.

    - Monitoring of groundwater. This will be carried out at one point, or more, situated upstream from the site’s inlet, according to the groundwater flow direction, and at two points downstream from the site’s outlet.

      The number of monitoring points could be increased on the basis of a hydrogeological survey of the area.

      The sampling frequency will be specific to each location and will be determined on the basis of the knowledge and assessment of the groundwater flow rate. The recommended parameters include pH, conductivity, heavy metals and anions.

- Monitoring of mercury vapor emissions and particulates with mercury content. A monitoring network should be established both within and outside the site to be remediated, to determine the environmental levels of mercury, and thus check the effectiveness of the remediation actions.

The duration of the MP and the sampling and data collection frequency generally depends on the environmental authority.

The following table shows some of the main parameters to include in a MP for a remediation project at a mercury-contaminated site, during implementation of the remediation activities.

MONITORING PLAN

MONITORED MEDIUM	MONITORING FREQUENCY	LOCATION	MONITORING PARAMETERS
Surface water	Monthly, first two years	Water upstream of the **immediate** surroundings of the site to be remediated	Temperature pH Conductivity Dissolved oxygen Redox potential (Eh) Nitrites COD Ammonia Mercury
		Water downstream of the **immediate** surroundings of the site to be remediated	
	Six-monthly, remaining years	Water upstream of the area **near** the site to be remediated	Temperature pH Conductivity Heavy metals: mercury.
		Water downstream of the area **near** the site to be remediated	Temperature pH Conductivity Heavy metals: mercury
	Annual	Water upstream of an area **further** from the site to be remediated	Temperature pH Conductivity Mercury
		Water downstream of an area **further** from the site to be remediated	
Groundwater	Monthly, first 2 years	Drilling around the site to be remediated	Mercury
	Six-monthly, remaining years	Drilling around the site to be remediated	Mercury
	Annual	Wells and springs around the site to be remediated	pH, conductivity, $HCO3^-$, $SO4^{2-}$, Cl^-, Ca^{2+}, Mg^{2+} , Na^+, $NO3^-$, $NO2^-$, $NH4^+$, mercury
Monitoring of meteorological data	Monthly	Site and surroundings	Direction, speed and frequency of prevailing wind
Monitoring of the mercury level in air	Monthly, first 2 years Quarterly,, remaining years	Site and surroundings	Level of mercury in the air
Monitoring of the mercury level in suspended matter	Monthly, first 2 years Quarterly, remaining years	Site and surroundings	Level of mercury in particles in suspension