Ministry of Environment

POPs Sustainable Management PMT

REMEDIATION OF POP PESTICIDES POLLUTED AREAS IN THE CONDITIONS OF MOLDOVA

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Addressing the Problem

- During the last decade pollution due to POP pesticides has been recognized by the Moldovan authorities as a problem of national priority which needs to be solved ;
- As a result of national inventory carried out in 2008-2010, about 1600 POP contaminated sites were identified and described (http://pops.mediu.gov.md).

HAZARD ASSESSMENT

Prioritizing of POPs contaminated sites

The Site Hazard Total Score was used for ranking the site hazard according to the five generic groups. The full set of investigated POPs sites were prioritized as follow:

Site Hazard Total Score	Site hazard rank	Site priority for remediation strategy	Action needs	Number of contaminated sites	
> 95 %	I	Very high	Urgent	76	4.8 %
65 – 95 %	II	High	In short-term perspective	467	29.7 %
35 – 65 %	III	Medium	In medium-term perspective	513	32.7 %
5 – 35 %	IV	Low	In long-term perspective	440	28,0 %
< 5 %	V	Negligible	General protective / low cost measures required	76	4.8 %

Addressing the Problem

- The study on remediation of POP pesticides polluted areas has been carried out complementary to the actions undertaken during last years in the field of sustainable POPs management, which included: inventory, repackaging, temporary storage and elimination of OP; strengthening the regulatory framework , capacity building and institutional strengthening for POPs management; awareness and educational activities;
- The specific objectives of this study were:

(i) to identify Best Available Technologies (BAT) for of POP pesticides polluted areas, applicable in the conditions of Moldova, taking into account technical, financial and economic aspects;

(ii)to assess their potential environmental/health benefits and impacts;

(iii)to implement appropriate remediation techniques at a few selected sites.

Addressing the Problem

- The remediation techniques had to be tailored to best fit local characteristics like ***soil type, hydrogeology, contamination degree, and pesticide category***.
- The identified techniques had to be tested/validated at selected pilot demonstration sites in order to identify methods most appropriate for Moldova with a view to recommendation of remediation strategies for other OP sites throughout the country pending the available financial resources.
- The study has been carried out within the ***CIDA/WB Project "Remediation of POP pesticide polluted areas and inventory of PCB contaminated oil in power equipment" by the NIRAS Consulting Engineers and Planners A/S (Denmark),*** and managed by POPs Sustainable Management Office (www.moldovapops.md).

Classification of POP pesticides polluted sites

- At the initial project phase criteria for selection of three demonstration sites to test remediation technologies were defined;
- Identification of different ***groups of site*** was based on the following considerations:

– Site conditions affecting choice of remediation technique, such as: contamination level, expected extent and location of soil pollution, soil characteristics, present land use with respect to remediation, need quick solution, ***site to be used / not to be used in the future etc.;***

  – The need for remediation, i.e. risk to human health and environment, including: contamination level, the proximity of OP sites to the residential or industrial areas, the proximity to the source of drinking water and surface water, to the agricultural land, pasture and livestock, to the protected nature areas and ecosystems.

Classification of POP pesticides polluted sites

- Based on the data available concerning the ***386 former OP warehouse***, the main criteria for classifying the sites has been as follows:

1. Soil pollution levels and potential for pollution in floors and walls – the national standard for soil pollution threshold for DDT and HCH is (0.1 ppm);
2. State of repair of the warehouse – integrity of walls, roof, door and windows determining the containment capacity of the building;
3. Threat to human health dependent on the proximity to sensitive human and ecological targets;
4. Type of soil under and around the warehouse classified either as permeable to rain water;

- When all 4 criteria were applied, only **40 records** which have the necessary information were selected.
- ***Final selection of <u>three demonstration sites</u> was selected after an in-depth analysis and supplementary site investigation***.

Evaluation of appropriate BATs for remediation

- The assessment of applicability of BAT Remediation Technologies for clean-up of pesticide polluted sites included aspects such as practical and economic feasibility for implementation in Moldova, taking into account:

– ***costs,***
– ***performance and efficiency,***
– ***treatment time in full-scale field trials; and***
– ***potential impacts on the environment and human health***;

- All selected BATs should already be tested and approved by international organizations (Secretariat of the Basel Convention, UNEP, UNIDO) and/or by relevant national authorities in other countries (e.g. US EPA);
- The selected BATs should not have adverse impacts on human health and the environment.

Evaluation of appropriate BATs for remediation

- ***The identification of suitable techniques for the clean-up of POP pesticide contamination was based on consideration of the following aspects:***
  - soil contaminants,
  - characteristics for soil pollution at former pesticide warehouse storage sites,
  - objectives for clean-up,
  - practical and physical restrictions for implementation,
  - economics,
  - performance and efficiency,
  - time-frame and need for post clean-up monitoring etc.,
  - environmental effects.
- ***The selection of relevant clean-up techniques was based on the ability to treat chlorinated pollutants such as DDT, Lindane (HCH), HCB and Heptachlor, as other POP pesticides have not been detected in soil samples;***
- **Two remediation (BAT) techniques have been chosen for the three demonstration sites with a view to possible further implementation in Moldova.**

Recommended BAT demonstration projects for Moldova

Enhanced Bioremediation usually involved mixing of the soil with additives to promote anaerobic conditions (zerovalent iron, hydrocarbons such as starch) and nutrients to enhance biological degradation.

- The Daramend technique involves sequential cycles of anaerobic (no oxygen) and aerobic (oxygen present) conditions;
- The anaerobic conditions generated by mixing an organic component with Daramend stimulate microbiological growth and dechlorination of the organochlorine containing pesticides;
- The dechlorinated products are removed by soil bacteria under aerobic conditions generated by tilling (ploughing) of the soil;
- ***According to the literature reports, at one full-scale treatment site, the Daramend technique reduced level of DDT and HCH by about 90%.***

Recommended BAT demonstration projects for Moldova

Isolation in controlled soil stockpiles (cofferdam) – the construction of a controlled soil stockpile ensures that the soil is removed and isolated with protective top and bottom liners:

- Isolation and management techniques ***cannot*** be considered as **"permanent solutions"** since the soil is still contaminated and the main disadvantage with this approach is that it is difficult to ensure that no future activities are carried out involving destruction of the cofferdam unless the end use of the site is restricted.
- The controlled soil stockpile should be fenced and equipped with warning signs, although this provides no guarantee to prevent future misuse.
- The integrity of the fence and cover layers of the soil stockpile need to be inspected regularly to ensure that no loss of structure integrity occurs to avoid unintentional contact and spreading of soil pollution in future.

Recommended BAT demonstration projects for Moldova

- **The major advantages** with this solution are:

i. the contamination will be removed so that no exposure to sensitive target can occur;
ii. it is a proven technique and efficient;
iii. it is simple and cheap and therefore can be realistic implemented by local authorities in Moldova at all kinds of site.

As it is important to improve the current situation and protect the people living close to the polluted areas and prevent further spreading of POPs to the environment, **it was recommended to demonstrate implementation of isolation technique and biological treatment** in a demonstration project at the former OP warehouse sites as these are well proven, quick and efficient techniques.

Remediation at the demonstration sites

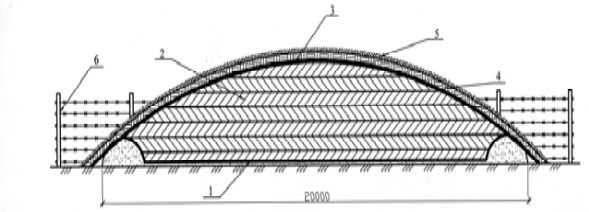
The bioremediation test included 10 cycles of Daramend application. The total surface of the test area was about 200 m². The depth of tilling was 25-30 cm.

Mean concentration in treatment and control areas before and after treatment with 5 and 10 cycles

	Area 1	Area 2	Area 3	Area 4	Area 5	Control area
Sum of HCH	mg/kg dw (mean values)					
Baseline before Daramend treatment	8.7	11.6	50.9	0.25	11.9	56.1
5 cycles Daramend	5.1	8.4	26	0.53	9.4	65.3
10 cycles Daramend	5.2	14	25	0.57	3.7	9.2
% reduction after 5 cycles of Daramend	41%	28%	49%	-	21%	-
% reduction after 10 cycles of Daramend	40%	-	50%	-	68%	85%
Sum of DDT	mg/kg dw (mean values)					
Baseline before Daramend treatment	35.9	10.5	12.9	0.57	22.8	1.5
5 cycles Daramend	12.7	2.2	5.5	1.3	13.5	0.99
10 cycles Daramend	6.6	0.48	1.4	0.22	4.5	0.99
% reduction after 5 cycles of Daramend	65%	79%	57%	-	41%	34%
% reduction after 10 cycles of Daramend	82%	95%	89%	61%	80%	34%
Heptachlor	mg/kg dw (mean values)					
Baseline before Daramend treatment	3.9	0.50	24.7	0.07	2.2	0.06
5 cycles Daramend	0.49	0.49	4.6	0.35	2.73	0.60
10 cycles Daramend	2.3	0.14	4.5	0.13	0.54	0,04
% reduction after 5 cycles of Daramend	87%	2%	81%	-	-	-
% reduction after 10 cycles of Daramend	41%	72%	82%	-	75%	-

Remediation at the demonstration sites

The cofferdam is a *constructed controlled pile* where contamination of the ground water from the content stored inside it is secured by a *bottom and top liner (membrane)* and contamination of the soil is secured against surface water and rainwater by a *bank around the pile* and a *top liner*.



1 - polyethylene film covering the bed of cofferdam (buttom membrane),
2 - contaminated soil and rubble placed in layers and compacted,
3 - polyethylene film covering cofferdam (top membrane), 4 - layer of topsoil,
5 - sown grass, 6 - fence made of concrete pillars and barbed wire (mesh).

Remediation at the demonstration sites


Bujor site before remediation


Bujor site after remediation


Training of local staff


Bujor Cofferdam, built on site


Congaz warehouse before remediation


Final stage of dismantling of Congaz warehouse


After site delivery


Congaz Cofferdam, built 3 km SW of Congaz

Economic evaluation

The economic evaluation of the BAT applicability included the direct and total costs as well as the unit price (efficiency) of both methods achieved during the remediation activities.

Comparison of Economic Aspects (1 Euro = 16 MD Leis)

		Congaz cofferdam	Bujor cofferdam	Step-Soci cofferdam	Bujor bioremediation
Amounts of soil and rubble treated,	m³	4 942	1 545	440	98
Time to achieve cleanup	Day	23	10	8	>70
Man hours required to complete	hr	864	264	126	120
Training hours need to complete	hr	2	2	2	2
Cost of treatment/materials	Leis	39 212	20 662	7 892	112 612
Cost of hire for equipment	Leis	170 450	76 650	26 600	44 246
Cost of manpower	Leis	19 440	5 940	2 835	1 950
Daily Rate, manpower , man/days	Leis	150	150	150	130
Costs of hire equipment, average	Leis	350	350	350	350
Direct costs	Leis	229 102	103 252	37 327	158 808
Total cost including taxes	Leis	408 297	196 964	71 307	158 808
Cost of PPE		21 419	11 953	5 380	2 767
TOTAL GENERAL		429 716	208 917	76 687	161 575
Price/ m³	Lei/m³	86,9	135,2	174,3	1 648,7
Achievement of clean-up goal		100%	100%	100%	50%
Need for maintenance		Yes	Yes	Yes	No
Need for follow up treatment		No	No	No	No
Applicability at other sites		Applicable	Applicable	Applicable	Applicable
Future maintenance		Needed	Needed	Needed	No
Need for future treatment		Yes	Yes	Yes	No
Future cost , treatment		Unknown	Unknown	Unknown	None

Conclusions

Lessons learned concerning appropriate remediation techniques that can be implemented by local authorities in Moldova can be summarized as follows:

- ***Priority for clean up activities:*** Risks should be reduced immediately as a top priority if there is risk to human health due to close proximity of the OP site to residential areas or vulnerable drinking water wells;
- ***Good detailed site investigations:*** The site investigation is the basis for decisions on the need for remediation and on the extent of remediation required;
- ***Start planning in good time:*** The planning process takes time and implementation is not possible in the winter months;
- ***Getting Works Permit:*** The demonstration projects experienced a number of delays due to the need for clarification on a number of legislative aspects concerning permits to start the work;
- ***Establish a local advisory facility:*** From the workshops and dissemination seminars, it is learned that the "site owners" needs a back up advisory facility from an experienced entity or consultant ;

Conclusions

- ***Use of PPE:*** Occupation health aspects involving use of Personal Protective Equipment (PPE) are easier to enforce if a short-term intensive construction project is initiated immediately after training in the use of PPE;
- ***Recommended remediation method is a controlled soil stockpile (cofferdam):*** As many sites have both contaminated soil and building rubble, the method of choice is to excavate the contaminated soil and rubble to a controlled soil stockpile (Cofferdam);
- If there are a number of smaller sites, there might be economical and management advantages to excavate the soil and waste materials and transport these to a local controlled soil stockpile site, so that maintenance costs can be reduced;
- ***Enhanced biological degradation is not directly applicable:*** The biological method by land farming whereby excavation is avoided is assessed not to be directly applicable in Moldova at former OP warehouses due to uncertainty about the clean up levels that can be achieved for the investment involved and due to the presence of contaminated rubble.

Remediation of POP pesticides polluted areas in the conditions of Moldova

Thank you!

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