Stockpiles of Obsolete Pesticides: Threat to Public Health & Biodiversity

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DECRG & ENV
The World Bank

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Tunisia

- Land Area: 155,400 sq km
- Population: 10 million
- Population Growth: 1.0%
- GNI Per capita: US$ 2,880
- National Poverty Rate: NA
- Adult Literacy rate: 74%
- Infant mortality Rate: 20 (per 1,000 births)
Stockpiles of Obsolete Pesticides

- Number of sites: 197
- Total quantity of chemicals: 1,984 metric tons

**Primary reasons for accumulation:**

1. Donation or purchase in excess of requirement
2. Poor stock management and inadequate storage
3. Products bans
4. Outdated / expired products
Stockpiles of Obsolete Pesticides: Framework for Hazard Assessment

Phase I:
1. Characterization of chemicals (by active ingredient)
2. Assignment of alternative “risk” or hazard indicators (WHO toxicity class, LD$_{50}$, chemical class, etc.)
3. Geographic overlays with distribution of total population, female population, children and population below poverty line
4. Identification of “hot spots”

Phase II:
1. Random monitoring of pesticide residues
2. Development of guidelines for resource allocation
Characterization of Chemicals:
Volume

From the Tunisia ASP database:

- Total quantity of chemical formulations: **1,984 metric tons** (759 metric tons of active ingredients)
- Each formulation is a combination of an active ingredient and a neutral carrier – we are interested in the toxicological properties of the active ingredient
- Total quantity of chemical formulations for which active ingredients could not be identified: **196 metric tons** (26% of the total)
- Total quantity of active ingredients identified: **563 metric tons** (74% of total)

### Identified Active Ingredients:
Condition of the Packaging

- Undamaged: 34%
- Surface damage: 11%
- Leakage: 30%
- Broken: 17%
- Contaminated Soil & Equipments: 8%
### Assignment of Hazard Indicator: WHO Hazard Classification

Active ingredients were then categorized according to the WHO classification system:

<table>
<thead>
<tr>
<th>Class</th>
<th>Quantity (metric tons)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO- Ia: Extremely hazardous</td>
<td>13</td>
<td>1.9</td>
</tr>
<tr>
<td>WHO- Ib: Highly hazardous</td>
<td>2</td>
<td>0.3</td>
</tr>
<tr>
<td>WHO- II: Moderately hazardous</td>
<td>196</td>
<td>28.3</td>
</tr>
<tr>
<td>WHO- III: Slightly hazardous</td>
<td>258</td>
<td>37.3</td>
</tr>
<tr>
<td>WHO-Table 5: Unlikely to pose health hazard</td>
<td>26</td>
<td>3.8</td>
</tr>
<tr>
<td>WHO-Other</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>WHO-Not classified</td>
<td>196</td>
<td>28.3</td>
</tr>
</tbody>
</table>
Distribution of Pesticide Stockpiles:
WHO 1a

Chemicals
1. Parathion
2. Ethoprophos
3. Fonofos
4. Mevinphos
5. Phosphamidon
6. Parathion-methyl
7. Brodifacoum
8. Chlorophacinone
9. Mercuric chloride
Distribution of Pesticide Stockpiles:
WHO-Ib

Chemicals
1. Carbofuran
2. Methidathion
3. Methomyl
4. Zinc Phosphide
5. Isofenphos
6. Cadusafos
7. Azinphos-Ethyl
8. Azinphos-Methyl
9. Heptenophos
10. Butocarboxim
11. Coumaphos
12. Demeton-s-methyl
13. Fenamiphos
14. Mecarbam
15. Mercuric Oxide
16. Methamidophos
17. Methiocab
18. Omethoate
Distribution of Pesticide Stockpiles: WHO-II

- < 5 kg
- 5 <= kg < 50
- 50 <= kg < 500
- > 500 kg
Assignment of Hazard Indicator:  
Chemical Class

Active ingredients were also categorized according to their chemical class with special categories for those known to have serious health effects:

<table>
<thead>
<tr>
<th>Chemical class</th>
<th>Quantity (metric tons)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organochlorine</td>
<td>139</td>
<td>20.0</td>
</tr>
<tr>
<td>Organophosphate</td>
<td>289</td>
<td>41.7</td>
</tr>
<tr>
<td>Carbamate</td>
<td>23</td>
<td>3.4</td>
</tr>
<tr>
<td>Pyrethroid</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Other classes</td>
<td>46</td>
<td>6.7</td>
</tr>
<tr>
<td>Unknown</td>
<td>195</td>
<td>28.2</td>
</tr>
</tbody>
</table>
Distribution of Pesticide Stockpiles & Population

Population density
- Low
- Medium
- Medium-High
- High
Potential Health effects:

- Brain tumor, Leukemia, Lymphoma and other cancers
- Asthma
- Problems with stamina, coordination, recall, etc
Organophosphates:
• Suspect carcinogen and mutagen, immunotoxin, fetotoxin, evidence of hormonal effects, decreased fertility through successive generations

Carbamates:
• Neurotoxin, suspect mutagen and fetotoxin, lung damage.
Organochlorines are persistent by nature.

Potential Health effects:
• Suspect mutagen;
• Asthma;
• Problems with stamina, coordination, recall etc.
Assignment of Hazard Indicator: 
**Acute Toxicity Indicator**

Active ingredients were then referenced for their $\text{LD}_{50}$ value (for humans, mammals, birds) and $\text{LC}_{50}$ value (for water, fish)

$\text{LD}_{50}$ = “Lethal Dose”: The amount given all at once which causes the death of 50% of a group of test animals (dose in mg/kg of body weight)

$\text{LC}_{50}$ = “Lethal Concentration”: Similar interpretation as above (dose in mg/liter)

**Indicator of toxicity**: The volume of active ingredient was then multiplied by $1/\text{LD}_{50}$ to give it a relative toxicity weighting or scale.

For example, consider 100 kg of a highly toxic substance ($\text{LD}_{50} = 0.1$ mg/kg) versus 100 kg of a relatively non-toxic substance ($\text{LD}_{50} = 5000$ mg/kg)

**Calculation**: 
Highly toxic = 100 x $1/0.1 = 1000$
Low toxicity = 100 x $1/5000 = 0.02$
Assignment of Hazard Indicator:  
**Acute Toxicity Indicator**

This calculation was performed for all active ingredients.

The toxicity-adjusted volumes were then categorized according to their LD$_{50}$ or LC$_{50}$ value.

For example, the Human Acute Toxicity Indicator is:

- **High Hazard:** Oral LD$_{50}$ < 50 mg/kg
- **Medium Hazard:** Oral LD$_{50}$ 50-500 mg/kg
- **Low Hazard:** Oral LD$_{50}$ > 500 mg/kg
Toxicity-weighted (LD50) Stock for Humans:

- High ( >2.165 kg)
- Medium (0.18 < kg <= 2.165)
- Low ( < 0.18 kg)
Geographic overlay:
Population Density & Hazard

Human Acute
Toxicity Indicator:
- High Hazard
- Medium Hazard
- Low Hazard
Assessment of Hazard to Ecosystems & Biodiversity

- Characterization of chemicals (by Active Ingredients)
- Assignment of hazard indicators ($\text{LD}_{50}$, $\text{LC}_{50}$)
- Computation of hazard-weighted chemicals
- Geographic overlays of National Park locations and species
  - Species Richness Assessment
  - Falco cherrug (IUCN red list)
  - Re-introduction (e.g. Oryx)
# Species Richness from National Parks

<table>
<thead>
<tr>
<th>Total species</th>
<th>National Parks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Taxon</strong></td>
<td>Zembra &amp; Zembretta</td>
</tr>
<tr>
<td>Mammals</td>
<td>&gt;&gt;</td>
</tr>
<tr>
<td>Birds</td>
<td>140</td>
</tr>
<tr>
<td>Macro invert.</td>
<td>200</td>
</tr>
<tr>
<td>Reptiles &amp; Amphibians</td>
<td>6</td>
</tr>
<tr>
<td>Fish</td>
<td>42</td>
</tr>
<tr>
<td>Flora terr.</td>
<td>266</td>
</tr>
<tr>
<td>Flora aqua.</td>
<td>149</td>
</tr>
</tbody>
</table>

>> = many species of mammals, birds, and reptiles

1. These National Parks do not have species counts

Source: Rapport National sur la Diversite Biologique (Table, p. 84)
Stockpiles and National Parks

Pesticides

Sources: IUCN WDPA and Birdlife International
Stockpiles and National Parks

contaminated buildings

Sources: IUCN WDPA and Birdlife International
Stockpiles and National Parks

contaminated equipment

Sources: IUCN WDPA and Birdlife International
Stockpiles and National Parks

Contaminated soil

Sources: IUCN WDPA and Birdlife International
Stockpiles and National Parks

metal contaminated containers

Sources: IUCN WDPA and Birdlife International
Stockpiles and National Parks

paper/cardboard
contaminated
containers

Sources: IUCN WDPA and Birdlife International
Stockpiles and National Parks

plastic contaminated containers

Sources: IUCN WDPA and Birdlife International
Stockpiles and National Parks

veterinary products

Sources: IUCN WDPA and Birdlife International
All ASP Stockpiles and National Parks

All ASP products

Sources: IUCN WDPA and Birdlife International
Assessment of Hazard to Ecosystems & Biodiversity

- Ecosystem and Biodiversity indicators
  - Falco cherrug area (IUCN)
  - Oryx re-introduction area
  - Distance to National Park (and Ramsar?)
  - Inside / outside threatened (IFPRI filtered) ecoregion
Assessment of Hazard to Biodiversity

Range map of a *Falco cherrug* assessed 2000

IUCN ENDANGERED

*Falco cherrug*
Oryx historic distribution

Source: Sahelo-Saharan Antelopes Status and Perspectives, Ed. Royal Belgian Institute of Natural Sciences, CMS SSA Concerted Action 2006, p16
Oryx historic distribution and IUCN National Parks

- Historic distribution based on White (1983)
- SSASP (2006) in red points

Source: Sahelo-Saharan Antelopes Status and Perspectives. 2006. Ed. Royal Belgian Institute of Natural Sciences, CMS SSA Concerted Action p16
Oryx Reintroduction: 3 NP’s

Number of introduced species (2003):
- Bouhedma NP: 136
- Sidi Toui NP: 32
- Oued Dekouk NR: 04

Historic distribution based on White (1983) in hatched blue

Source: Second seminaire regional sur la conservation et la restauration des antilopes sahelo-sahariennes, 1-5 May 2003
## Tunisia: Ecoregions

<table>
<thead>
<tr>
<th>Ecoregion</th>
<th>Conservation Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mediterranean Woodlands and Forest</td>
<td>Critical / Endangered</td>
</tr>
<tr>
<td>Mediterranean Conifer and Mixed Forest</td>
<td>Critical / Endangered</td>
</tr>
<tr>
<td>Northern Sahara Steppe and Woodlands</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>Saharan Halophytics</td>
<td>Relatively Stable or Intact</td>
</tr>
<tr>
<td>Mediterranean dry woodlands and steppe</td>
<td>Vulnerable</td>
</tr>
</tbody>
</table>

*Source: WWF Ecoregions*

[www.worldwildlife.org/wildworld](http://www.worldwildlife.org/wildworld)
Assessment of Hazard to Ecosystems & Biodiversity

WWF Eco regions
www.worldwildlife.org/wildworld

Mediterranean woodlands and forests (PA1214)

Where Africa and Europe meet
Special Features
Did You Know?
Wild Side
Cause for Concern
More Photos

El Feidja National Park, Tunisia
Photograph by © WWF-Canon/Michel GUNThER

WHERE
Northern Africa: Morocco, Algeria, and Tunisia

BIOME
Mediterranean Forests, Woodlands, and Scrub

SIZE
138,200 square miles (357,900 square kilometers)
-- about twice the size of North Dakota

CONSERVATION STATUS
Critical/Endangered

Where Africa and Europe meet

The Mediterranean Woodland and Forest runs through Morocco, Algeria, and Tunisia, lining the Mediterranean coast and facing the European shore. The low-lying coastal plain turns to rugged hills further inland, and then surrounds but does not include the Atlas Mountains. Summers are hot and dry here, with mild and humid winters. Offshore currents further alter climate, and combine with varied landforms and geology to result in an amazing variety of forest types. Dry pine forests mix holm oaks and junipers, cork oak forests grow along the coastal plains, and wild olive and carob woodlands grow in short scrubby vegetation.
Assessment of Hazard to Ecoregions

WWF Eco regions

www.worldwildlife.org/wildworld
Assessment of Hazard to Ecosystems & Biodiversity

WWF Eco regions
www.worldwildlife.org/wildworld

Mediterranean conifer and mixed forests (PA0513)

- An African Winter Wonderland
- Special Features
- Did You Know?
- Wild Side
- Causes for Concern

More Photos

An African Winter Wonderland

When you imagine an African forest, you probably don’t picture snow-covered evergreen trees. But if you were to visit this ecoregion during the cold season, you might think you’d stepped into a winter wonderland! Here in the mountains of northern Morocco and Algeria, moist conifer and mixed broadleaf forests flourish. The air is misty and damp, and in the higher elevations winter snowfalls are common.

Special Features

This ecoregion has an extremely high number of endemic and relict plant species. The Marocano fir—with its thick, twisted, and forked trunk—is found only in the Rif Mountains of Morocco. And, in the mountains of Algeria, Algerian firs may grow as tall as 65 feet (20 m). Small clusters of rare conifer trees survive in only a few isolated areas where the air is particularly cold and moist. These mountain forests are important stopovers for birds migrating between northern Europe and Africa.
Assessment of Hazard to Ecoregions

WWF Eco regions

www.worldwildlife.org/wildworld
Ichkeul National Park

- **Critically Endangered**
- **Endangered**
- **Vulnerable**
- **Near Threatened**

**Gazella cuvieri**

**Oxyura leucocephala**

**Heptranchias perlo**
Stockpiles near Ichkeul National Park

- Four storage sites at Mateur (label 1) and Menzel Bourguiba (label 2) within 5 km of the park boundary.
- 19% of the pesticides at Mateur indicates leakage, and 100% of containers at one storage site at Menzel Bourguiba shows surface damage.
- Mateur has 807 kg of extremely hazardous, persistent organic pollutant Parathon-Methyl in stock.
- Menzel Bourguiba has organochlorine compounds in stock.

LC50 weighted Active Ingredients indicate likely hazard (red = high risk; pink = medium risk; grey = low risk) for aquatic environment & fish species.
Data Sources:

Data

- Amphibian habitat: Global Amphibian Assessment
- Bird habitat: Birdlife International
- Fish occurrence: FishBase
- Mammal habitat: Conservation International / IUCN
- IUCN species status: IUCN
- Terrestrial and Marine Ecoregions: WWF
- Basin delineation and flow accumulation based on HydroSHEDS
- Delegation spatial units: Agence Nationale de Gestion des Déchets
- Elevation: SRTM 90m
- Perennial river: FAO
- Population: Institut National de la Statistique (RGPH 2004)
- Wetlands: Ramsar
Assessment of Hazard: Phase II (Proposal)

In selected “hot spots”:

- Monitoring and quantification of High-Hazard Pesticide Residues in:
  - Soil
  - Surface & Ground Water
  - Vegetation
  - Critically Endangered/ Endangered/ Vulnerable Mammals, Birds, Amphibians, Fish