WASH TECHNICAL PAPER

REDUCING THE ENVIRONMENTAL IMPACTS OF VECTOR CONTROL CHEMICALS IN EMERGENCIES

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1. AIM OF THIS BRIEF

Disasters and their aftermath of destroyed infrastructure – debris, displaced populations and damaged sanitary services – create environments in which vectors can increase dramatically, posing significant health challenges. Insects such as mosquitoes, flies and fleas, and rodents such as rats and mice can transmit a wide range of diseases which can increase the suffering of disaster survivors and lead to unnecessary mortality. Table 1 summarises some of these vector-disease linkages.

Post-disaster sanitary and hygiene efforts need to create an environment where vector breeding and nesting sites and the opportunity for vectors and human contact are removed or reduced to a level which makes the disease threat of vectors inconsequential. This short note on Reducing Environmental Impacts of Vector Control Chemicals in Emergencies provides guidance to WASH practitioners on how to effectively limit the impact of vectors, as well as the environmental impact of chemical control measures which are often used in vector control.

The information contained in this note is intended to help planning vector control efforts. However, further review of the documents listed in the Section 5, Further Resources, is recommended before launching a full scale vector control programme.

2. ENVIRONMENTAL MODIFICATION

The core concept to reducing the health threat posed by vectors is environmental modification, that is creating environments where specific vectors cannot exist, or where their presence is so minor to not pose any threat to health.
The objective of environmental modification for vector control is to eliminate contact between vectors and vulnerable populations. Eradicating vectors per se is both impractical and could result in significant damage to the environment by disrupting food chains and ecological balance. The basic approaches to vector control through environmental modification are to:

- remove or reduce the locations where vectors breed to reduce the number of vectors threatening humans; and
- create appropriate barriers for the remaining vectors to further eliminate contact with humans.

Environmental modification includes a range of actions associated with effective sanitation and hygiene, as described below.

There are four reasons why the use of chemicals is the least preferred way to modify environmental conditions consusive for vectors of concern:

1. Pest control chemicals, the equipment necessary for their safe use and disposal and the logistics required for proper control efforts, are costly. If there are other ways to achieve the same goal at lower cost, they should be used.

2. The organisation of chemical control operations is complex and requires trained personnel and oversight. Other forms of environmental modification are less complex and easier to implement.

3. Many pest control chemicals used in emergency operations are non-specific, that is they can impact beneficial insects as well as the vectors targeted for control.¹

4. Pest control chemicals are often highly toxic. Mistakes in the use, storage and disposal of pest control chemicals can lead to human and animal poisoning and death.

<table>
<thead>
<tr>
<th>Vector</th>
<th>Associated Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mosquitoes</td>
<td>Malaria, yellow fever, dengue, viral encephalitis, filariasis</td>
</tr>
<tr>
<td>Houseflies</td>
<td>Diarrhea, dysentery, conjunctivitis, typhoid fever, trachoma</td>
</tr>
<tr>
<td>Cockroaches</td>
<td>Diarrhea, dysentery, salmonellosis, cholera</td>
</tr>
<tr>
<td>Lice</td>
<td>Endemic typhus, pediculosis (head, &quot;crab&quot; or body lice), relapsing fever, trench fever</td>
</tr>
<tr>
<td>Bedbugs</td>
<td>Severe skin inflammation</td>
</tr>
<tr>
<td>Sand Flies</td>
<td>Leishmaniasis</td>
</tr>
<tr>
<td>Triatomid bugs</td>
<td>Chagas disease (American trypanosomiasis)</td>
</tr>
<tr>
<td></td>
<td>(This vector is also known as “Kissing”, “Conenose” and “Assassin” bugs)</td>
</tr>
<tr>
<td>Ticks</td>
<td>Rickettsial fever (e.g. african tick-bite fever), tularemia, relapsing fever, viral encephalitis, borrellosis, e.g. lyme disease</td>
</tr>
<tr>
<td>Rodent (mites)</td>
<td>Rickettsial pox, scrub typhus</td>
</tr>
<tr>
<td>Rodent (fleas)</td>
<td>Bubonic plague, endemic typhus</td>
</tr>
<tr>
<td>Rodents</td>
<td>Rat bite fever, leptospirosis, salmonellosis, melioidosis – Whitmore’s disease</td>
</tr>
</tbody>
</table>

¹ While vector-specific pest control chemicals are increasingly available their immediate availability in an emergency context is not certain making it likely that more widely available but less specific pesticides will be used in emergency control operations.

These points are raised not to argue that pest control chemicals should not be used, but that they should, in general, be used as a last resort, and based on clear analysis that the cost associated with chemical control are offset by the expected benefits to human health.

The second core concept is the use of barriers to keep vectors from locations where they can pose a health risk. Screened windows and insecticide-treated mosquito nets are two common barrier methods to limit contact between vectors and humans. Traps can be used as another form of barrier, as is the simple blocking of access points into structures where vector breeding takes place, for example, latrines, or where vectors come in contact with humans, for example in kitchens.

The means to reduce breeding and create barriers vary by vector and physical setting. Most means of environmental modification
relate directly to proper sanitation and hygiene practices, basically maintaining a clean environment.

The context of environmental modification is different when disaster-affected populations are located in organised camps, or other communal settings and when they are located near or at their normal residence. Camps settings permit barriers to be integrated into the design of a camp site and facilities as well as highly targeted public sanitation and control efforts. Similar efforts for dispersed populations can require more social mobilization and outreach efforts, although when developed and managed efficiently, these efforts can be very effective.

3. SURVEILLANCE

A key element in a successful vector control programme— and hence reducing negative environmental impacts of such programmes – is the surveillance of possible vectors. Information generated through surveillance efforts is necessary to select the appropriate pest control methods, the concentrations of chemicals used and the application methods and locations. Surveillance can range from the simple – are there any flies present? – to the complex, for example, assessing whether specific pest have developed resistance to a particular pesticide formulation.

In general, the early stages of most emergency operations do not provide time for more than simple surveillance methods which might consist of the following:

- **monitoring the visible presence of vectors**— can flies, cockroaches, mosquitoes, rats or other vectors be seen? Note that some vectors may be more present at night and that disaster-affected populations are likely to be very aware of the presence of the most common vectors;
- **searching for vectors in locations where they may breed or reside**— these sites are most often in areas not common to human traffic, such as under debris piles, between walls, in sewage systems and in areas of standing or flowing water; and
- **searching for evidence of specific vectors**— for instance, looking for rat faeces in food handling areas, lice in clothing or bed bugs in bedding.

These three surveillance methods can be formalised into reporting forms using a checklist approach with staff assigned to regularly conduct surveillance visits. Undertaken on a regular basis, this process can be used to compare vector presence before and after control operations.

The longer a shelter site – a camp or communal housing— remains in existence the more sophisticated surveillance methods can become. The next step-up from that described above is the collection of vector samples and testing them for the presence of specific diseases. The need for this level of effort should be assessed at the beginning of an emergency operation and implemented with the assistance of specialised pest control experts. The capacity and/or interest of the local authorities or other bodies responsible for such surveillance should be assessed as early as possible.

4. CHEMICAL CONTROL\(^2\)

Chemical control can present a number of challenges which need to be carefully planned and properly managed if these efforts are to be successful. In this context, success is defined in terms of the safe use of hazardous materials, the use of the smallest quantity of chemicals necessary to limit the vector threat, as well as the total body count of vectors killed.

4.1 Safety

Safety is paramount in chemical control operations. Some pesticides are, by nature,

\(^2\) While not strictly chemicals, the use of biological control agents is included in this section.
toxic and may be deadly to humans, even in relatively small quantities.

A key tool in developing a **Safety Plan** is a Material Safety Data Sheet (MSDS) for the pesticides to be used in control operations. MSDS are normally included with pesticide shipments (e.g., attached to a pesticide barrel or included in packaging). MSDS information can also be downloaded from the World Wide Web (see [http://www.pested.psu.edu/resources/web/labels/?searchterm=msds](http://www.pested.psu.edu/resources/web/labels/?searchterm=msds)). A Safety Plan should also incorporate information from the pesticide label. This label should include directions and precautions for the use of the pesticide, first aid actions and guidance on pesticide and container disposal.

A Safety Plan should be developed for each chemical control operation and include the following elements:

1. A technical description of the substance to be used, including:
   - the formulation to be used;
   - likely routes of human intoxication, e.g. trans dermal or oral;
   - information on symptoms of intoxication and treatment;
   - conditions under which and locations where the pesticide should not be used; and
   - protection measures for applicators and during application.

   This information should be shared with medical personnel who would likely receive pesticide poisoning victims. Much of this information is available from a pesticide supplier or manufacturer.

2. Information on the safe handling and application of the pesticide being used, including applicator protection measures. Again, this should be readily available from the pesticide manufacturer/ supplier and the application equipment supplier/manufacturer.

### What is in a MSDS?

A MSDS normally includes information on:
- The ingredients in the chemical compound.
- Physical and chemical properties of the compound.
- Additional hazards (e.g., flammability).
- Routes of entry (e.g., oral, trans-dermal).
- Exposure limits.
- Safe handing and use.
- Emergency first aid.
- Sources of additional information (e.g. a number to call or web site to visit).


3. Guidance to populations where the pesticide will be used on limiting contact and avoiding contamination, e.g., covering water and food supplies. This guidance should be formulated into a public information campaign to be launched before any pesticide is applied.

4. Written procedures for the safe transport, formulation and application of the pesticides, detailing action to be taken in the case of accidents, spills or apparent intoxication. This information is available from standard texts on pesticide application.

### Pesticide Application Methods

- **Dusting** – Hand-held dusters, manually operated or mechanised.
- **Residual insecticide** – Knapsack sprayers with special nozzles.
- **Ultra-low volume** – Low-dosage applications to spraying large areas from fixed-wing aircraft or helicopters.
- **Space spraying** – Interior or exterior applications with pesticide aerosols dispersed under pressure from vapourisers or fogging machines.
- **Impregnation** – The treatment of materials such as bedding, clothing and mosquito nets with pesticides in emulsion or solution, by dipping and drying, or by spraying with knapsack sprayers.

operations and training.

5. A justification for the selection of specific pesticides for the treatment of specific vector problems.

6. The results of any environmental review of the use of the pesticide.

7. A plan for the disposal of all empty pesticide containers and the cleaning and decontamination of treatment equipment and applicators.

The safety plan should be publically available and used in the training of applicators and other personnel involved in pesticide use operations.

4.2 Assessment

Any planned use of pesticides should be based on an assessment of the following:

- the presence of vectors in numbers which pose a human health risk;
- potential human consequences of a vector-linked health event, e.g. a significant upsurge in malaria;
- effectiveness of non-chemical control measures – alternatives to pesticide use should always be considered in the planning of any control operation;
- environmental and economic costs involved; and
- public willingness to allow the use of pesticides.

The decision to use chemicals control measures should be based on a joint decision of health and pesticide control experts. The surveillance information described above is also critical, as it is likely that chemical control operations will be needed when the numbers of a specific vector exceed other environment management control efforts.

4.3 Planning and Monitoring

A plan for the use of pesticides should cover the following points.

1. A statement of the specific vector problems to be addressed.

2. The key points of the safety plan described above. (The full safety plan should be an annex to the pesticide use plan.)

3. Justification for the use of specific chemicals and treatment methods, with alternative considered.

4. A review of any legal or regulatory requirements which need to be met during pesticide used.

5. A public information plan, based on and expanded from the safety plan.

6. An organisation chart, with the responsibilities of the main staff noted.

7. A logistics plan covering the procurement, transport, processing – e.g. formulation, breaking large volumes of pesticide down to smaller application-level volumes – storage and disposal of containers and other materials. The logistics plan should include a spill management component if this has not already been covered in the safety plan.

8. A plan for monitoring the:

- application of the pesticide(s);
- health conditions of applicators, pesticide handlers (including vehicle drivers), control programme staff and populations in areas where pesticides are used; and
- impact on target vectors and non-target species.

9. A training plan, with materials in appropriate language(s) identified.
10. A budget.

Full details on planning a chemical control programme can be found in Emergency Control of Vectors Using Chemicals: Chapter 4, Overall Process for Implementing a Vector Control Programme.

4.4 Selecting the Correct Treatment Method and Chemical

The selection of the correct control chemical depends on a number of factors, including:

1. **Cost** – some pesticide preparations (e.g. wetable powders) are less expensive than others and some application methods are considerably more expensive than others.

2. **Vector breeding and impact areas** – Vectors which inhabit closed spaces, e.g. mice, require different chemicals and application methods than those which occupy open spaces, e.g. mosquitoes.

3. **Area to be covered** – localised use of chemicals is more appropriate for rodent control, while space application may be more appropriate for flying insects such as mosquitoes.

4. **Urgency** – if the need for vector control is immediate, then chemicals which can be used quickly, and which have a quick impact will need to be used.

5. **Regulations** – the selection and application of a vector control chemical needs to comply with government regulations and, in some cases, with possibly more restrictive regulations of those who are funding the application. These regulations may define:
   - that only a single or a limited number of chemicals can be used to control a vector;
   - how these chemicals may be used, e.g., spraying or dusting; and
   - the steps which need to be taken to limit unwanted impacts, e.g. prohibiting application near water bodies, or use in inhabited locations.

Considering the factors above, the first steps in selecting a vector control chemical are to:

- identify the vector to be controlled;
- identify what pesticides are authorised to control this vector, both by national regulation or those of the programme funder; and
- refer to a pesticide application expert on the best methods and approaches to using chemicals for vector control. These experts may be available locally or through the World Health Organization (via WHOPES, see below) and the Food and Agricultural Organization (Pesticide Management Unit, Plant Protection Service, http://www.fao.org/agriculture/crops/core-themes/theme/pests/pm/en/).

4.5 How to use Chemical Control

In the early stages of an emergency, it is likely that pest control chemicals will be used to knock down vectors which are considered a threat. For instance, urgent mosquito spraying operations may be needed to reduce the risk from malaria for displaced populations in a tropical environment.

However, vector control programs should not rely solely on chemical control, but use chemical control as one of several methods to control vectors of concern. For instance, a mosquito control effort which starts with a knock-down campaign using chemicals should be followed by activities to reduce breeding areas and establish barriers to transmission (e.g., distributing mosquito nets). While chemicals can be part of this extended control effort (e.g., residual spraying, treated bed nets), a reliance of chemicals for control should be limited to the greatest degree possible to limit negative impacts on the environment.
5. FURTHER RESOURCES

A considerable literature has developed over the years on chemical control of vectors. In using this literature two points need to be kept in mind:

1. The chemicals and biological agents used to control vectors are evolving from substances which have a broad effect on the environment to ones which have limited and sometimes very targeted impacts on specific species, or stages of species development.

2. Application methods and tools are also evolving and so even relatively recent documents may not include the most advanced tools and methods being used.

The World Health Organization has developed a Pesticide Evaluation Scheme (“WHOPES” – http://www.who.int/whopes/en/) as a source of information on the selection and use of public health related pesticides. WHOPES should be used as a primary source of information to develop vector chemical control programmes and select the most appropriate equipment and pesticides.


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