# Stopping stockpiles

*Disposal of obsolete pesticides is a vital first step in eliminating the hazard of stockpiles. But it can be just as difficult to identify concrete actions that will prevent future stockpiles. PAN UK is the independent monitor for the obsolete pesticide project in Mozambique.* ***Eloise Touni*** *reports on progress being made on prevention work.*

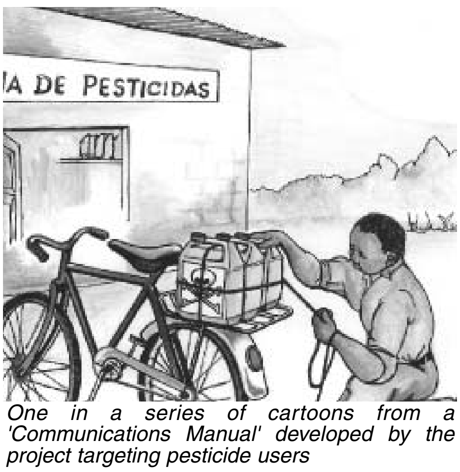
The government of Mozambique is currently managing a project to remove obsolete pesticides. With financial assistance from the government of Japan and technical assistance from the Food and Agriculture Organisation of the United Nations (FAO), government teams have completed a national inventory, and are in the process of repackaging and centralising over 500 tonnes of obsolete pesticides from almost 200 stores. An integral part of the project is to ensure that once these are removed future stockpiles do not accumulate.

The first stage in the project is to conduct a national inventory of all existing stockpiles. Working with provincial ministry of agriculture and ministry of environment staff teams, a national inventory was compiled in 2003/2004. For each of almost 200 stores, the inventory records the quantities (number and type of containers, as well as total amount), types of pesticide (formulation, active ingredient, product name) and basic information on the condition of the stocks, including expiry dates and photographs of labels if possible.

A consultant was employed to analyse the inventory data, interview key stock owners (see figure), provide an analysis of the causes of accumulation and recommendations for preventative steps.

## Causes of stockpiles

The research concluded that ministry of agriculture stocks were largely due to poor responses to migratory pest invasions: uncoordinated donations of pesticides as aid (a practice now largely stopped); and poorly planned procurement: the ministry of agriculture now only imports pesticides for migratory pest control. A lack of awareness and training among private and public sector storekeepers and distributors of pesticides also contributed, although larger private sector importers do now provide some training for approved distributors and retailers. While some of the causes of obsolete pesticide accumulation are historic factors that are now largely irrelevant, many result from long-established practices and habits, which require long-term shifts in awareness, training, and understanding. Lack of financial, technological and human resources also played a role. Informing users about proper pesticide management is essential to prevention in the long term. The communication strategy underlies the entirety of project activities, including the specific recommendations made by the prevention consultant.



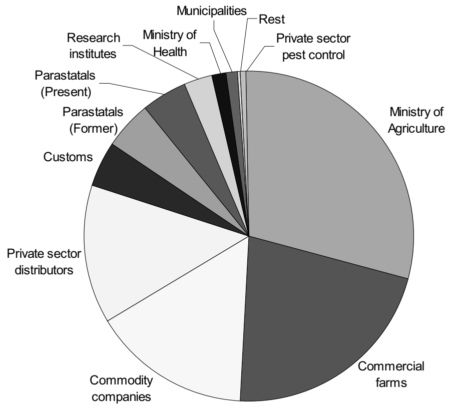

*One in a series of cartoons from a 'Communications Manual' developed by the project targeting pesticide users*

## Preventative action

A number of steps were identified that could prevent future stockpiles:

- Communication and information sharing: What pesticides are being imported, in what quantities, by whom, for what use and which users? Although the Ministry of Agriculture and customs share some information, large gaps were identified, and there is no centralisation of pesticide statistics or public access to that information.
- Migratory pest control: migratory pests (locusts and the red army worm) are hard to plan for; pesticides stored to counter a pest which does not arrive will eventually become obsolete. If the government keeps funds to purchase pesticides, delays in purchasing could catastrophically delay any response. An advance strategy to minimise the risks of unusable pesticides is needed.
- Long term capacity for dealing with pesticide wastes: even in the best circumstances, pesticides will expire, as manufacturers only guarantees them for two years from the date of manufacture. Empty, contaminated containers are also classified as obsolete pesticides, yet they could be recycled, as demonstrated by schemes operating in various countries, such as Brazil (this issue p16), or triple rinsed and disposed of in an appropriate landfill site.
- Monitoring and enforcement: as in many African countries, actual control over pesticides is very limited - even when regulations and guidelines exist, they are not properly enforced due to a lack of capacity and resources within the Ministry of Agriculture inspection or enforcement departments. This lack of control, for example over illegal imports over very long and porous borders, is a significant barrier to successfully preventing pesticide wastes.
- An 'integrated pest management' (IPM) approach to dealing with pests is a philosophy that overhangs the entire prevention work. Replacing toxic pesticides with pest control which uses cultural and biological controls and only uses conventional chemicals as a last alternative, will reduce the amount of pesticides available to become obsolete. If natural products are used, they will not become hazardous wastes, and can be dealt with as part of a normal waste management framework. IPM pilot projects demonstrate that crops can be grown with up to 100% reduction in pesticides used – with corresponding reductions in obsolete pesticides.

### Ownership of existing pesticide stocks in Mozambique




While a one or two year project can help identify and make a start on addressing some of these basic causes, the kinds of changes required are often long term and involve national actors. The short term projects face significant challenges to safely and completely remove existing stocks, and do not have the authority or remit to follow through with all the prevention actions needed.

One of the key factors in successful prevention is engaging a committed multi-stakeholder group. Current stocks are owned by a diverse range of owners (see figure). In addition there are other stakeholders – for example, smallholder farmers (whose stocks are not in the inventory), legislators and regulators who define and control obsolete pesticides, government bodies responsible for agricultural advice to farmers, pesticide marketing bodies, international aid bodies, and more. The stockpile project is governed by a National Steering Committee representing a number of these stakeholders, and meets regularly with the project management. This is a good opportunity to hand over responsibility to the government, private sector, and civil society organisations who are represented on the steering committee, and to encourage them to take the necessary actions.

*www.virconn.com/martinho/faodev/Docs/Projects/ObsoletePesticides/website_en/index.htm*

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# Pesticide risk assessment – inadequate for occupational exposure

*Manufacturers of pesticides are required to submit data to national regulators to allow health and environmental risks to be assessed before pesticides can be registered for use in a country. However, procedures for assessing the hazards of pesticides and the likely worker exposure are incomplete making assessment of risk very uncertain.*

Farmers and agricultural workers are exposed to pesticides regularly or even daily and so it is vital to understand the hazards posed by these chemicals and the likelihood of worker exposure. A process of risk assessment is carried out by national regulators before pesticides are registered for use in a country. This process aims to estimate the likelihood and extent of injury to humans or wildlife resulting from use of the pesticide and serves to provide users and authorities with a basis for making informed decisions on how to control such risks. Assessing the risks of pesticides in the workplace is an established part of risk assessment in industrialized countries, but in many developing countries is not included within pesticide registration.

## Hazard

The process of risk assessment includes an evaluation of both hazard and exposure. The hazard of a substance consists of physical, chemical and toxicological properties that define its potential for damaging organisms or the environment. It is a basic quality of the substance and is characterized by identifying specific adverse effects caused at a range of doses in cultured cells or in animals (usually the most sensitive species is tested).

In situations where a chemical has been in use for some time the hazard can be assessed, either by comparing the incidence of illness among workers exposed to the chemical with that among non-exposed workers (cohort study), or by comparing the exposures between individuals with and without illness (case-control study).

## Exposure

Specific circumstances determine the amount of substance people are exposed to[1]. This depends on its physical state, volume, concentration, the duration and pathway of exposure (for example dermal, inhalation, ingestion), spraying equipment, weather, protective clothing and hygiene. Both workers handling pesticides directly and workers entering treated areas are exposed. In industrialised countries workers are generally afforded a high level of protection, for example spraying from within enclosed tractor cabs. Whereas in developing countries workers apply pesticides largely using backpack sprayers with minimal protection. For unprotected workers exposure to the concentrated pesticide tends to be largely via the skin, particularly on the hands, during mixing of concentrated solutions, while other parts of the body are exposed to dilute pesticide during spraying, especially in windy weather[2]. It is difficult to assess accurately the level of exposure during pesticide application as it is affected by many variables and may occur simultaneously via several pathways.

## Risk

Risk is defined as the probability of an adverse effect in an organism, population or ecosystem caused under specific circumstances by exposure to a substance[3]. It is based on both the inherent hazards of the substances and the likelihood of exposure. A substance that is classified as moderately hazardous but used under conditions leading to higher human exposure may still be regarded as high risk. Risks are increased if a pesticide is either more hazardous or if exposure is higher. A measure of risk is the degree to which the estimated exposure exceeds an exposure limit regarded as safe[4]. It is vitally important to have accurate and unbiased estimates of risk so that appropriate measures can be taken to control them[5]. However, uncertainties in the assessment of both hazard and exposure contribute to uncertainties in risk evaluation.

An alternative approach to assessing pesticides is to regulate according to the hazardous properties inherent in pesticides, such as persistence, toxicity, or bioaccumulation[6]. The European Union's (EU) biocidal products directive, which applies to non-agricultural pesticides, prohibits active ingredients that are carcinogenic, mutagenic or toxic to reproduction, an example of regulation according to hazard rather than risk[7].

## Risk mitigation

National pesticide regulators carrying out risk assessment must decide what level of risk is acceptable and must identify measures for reducing risk. Farm workers are likely to be the most highly exposed group and exposure during mixing, loading and application is often substantial. Risk mitigation measures may include restricted availability of a pesticide, require closed containers, specific formulations, or that workers wear protective clothing and other personal protective equipment. However, risk mitigation measures may in some cases be impractical and in others may not be followed[8]. On plantations in Costa Rica workers were continually at risk of high exposure levels due to poor working conditions, and using personal protective equipment did not provide adequate protection as pesticide sprays can get under clothing or soak into it, and can get into gloves or boots[9]. In the EU, directive 91/414/EEC requires that workers' exposure to pesticides is assessed under proposed conditions of use and the risk evaluated by comparing potential exposure with an acceptable exposure level[10].

## Establishing safe levels of exposure for operators

The authorisation procedure in the EU requires that manufacturers supply information allowing the foreseeable risks that a pesticide may pose to human and animal health, and to the environment, to be assessed[11]. This includes data on acute, short-term and chronic toxicity, and operator exposure[12]. Laboratory toxicity tests are conducted on animals and the highest level at which no harmful effect is observed is called the 'no-observed-adverse-effect level' (NOAEL). The NOAEL calculated from animal studies is then used to estimate a dose which would be expected to have no effect in humans[13].

The acceptable operator exposure level (AOEL) is defined as the maximum amount of active substance to which the worker or 'operator' may be exposed by all routes without any adverse health effects (measured in mg substance per kg body weight). The AOEL is an estimate and is established by dividing the NOAEL by 100. This safety factor is introduced to account for the uncertainties of extrapolating from animals to humans (humans may be more sensitive than the test animal) and individual differences in susceptibility (one human may be more sensitive than another). Data should provide a basis for choosing appropriate protective measures, including re-entry intervals. No pesticide can be authorised if workers are exposed above the AOEL under the proposed conditions of use and unless protective equipment is effective, readily obtainable and its use is feasible, taking into account climatic conditions[14].

## Estimating operator exposure

Different methods exist for evaluating exposure. Experimental measurements can determine the degree of operator exposure: cotton patches fixed onto the body or pesticide sprays spiked with fluorescent dyes can determine the amount of substance on bare skin or clothing[15] and air samplers can assess the amount of spray breathed in. This experimental data has been used to develop models that can predict exposure for known scenarios based on chemical properties. Epidemiological studies can also be used to estimate exposure from job history and estimated exposure levels for different jobs (using questionnaires, measurements, models and/or assumptions)[16,17,18].

Biological monitoring can validate the estimates[19]. For example, a biological marker of the level of exposure to organophosphates or carbamates is the concentration of the enzyme cholinesterase present in blood plasma. However, plasma levels of cholinesterase recover shortly after exposure and can also be affected by impaired liver function[20]. A more reliable method of assessing acute exposures is to measure cholinesterase in red blood cells. Biological monitoring of pesticides allows determination of the total uptake or actual exposure but does not distinguish between exposure routes. Toxicology has focused on the oral route, but this is not always the main route of exposure. Assessment of workers' exposure needs to identify the primary exposure routes if appropriate risk mitigation measures are to be identified[21].

Many variables influence the level of operator exposure, including environmental conditions, chemical properties, crop, equipment, protective clothing and operator technique. Exposure assessments to be used in developing countries must therefore be based on local practices and conditions and not on ‘best practice’ in industrialised countries[22]. For example, in Nicaragua factors that increased exposure were temperature, use of a hand-pressurised sprayer, volume of sprayed solution, spraying with the nozzle directed in front, splashing on the feet, and gross contamination of the hands[23]. The most significant factor giving rise to variability in exposure was working practice which accounted for half the variability. Skin exposure to pesticides can be substantial and arises from splash, contact with contaminated surfaces and deposition of airborne droplets onto skin[24].

A US study found that herbicide levels measured in the urine of applicators were related to pesticide formulation, protective clothing, application equipment, handling practice, and personal hygiene[25]. A Southern European study in glasshouses showed crop height and row spacing were the most important factors[26]. It is well accepted that hand-held sprayers result in much higher levels of operator exposure than tractor spraying[27]. Another US study found that during mixing and spraying of pesticides 87-95% of overall exposure was via the skin, and 5-13% via inhalation; estimated dermal exposure of workers (wearing full-length trousers, long-sleeved shirts, shoes and socks) was greatest during application with manual spraying equipment (1.04 mg per hour mean)[28]. Mean exposure during the mixing or loading from open pouring of liquid formulations was almost twice as high (1.89 mg/h) as during application and was four times as high during open handling of granular formulations (4.14 mg/h). In a study of certified applicators using hand-held lances in greenhouses 99% of potential dermal exposure (the amount on clothing and skin) was via the hands during spraying. During mixing and loading it was distributed more evenly to all body parts[29]. Accidental leakage contaminated a workers' hand in this study, causing a more than sevenfold increase over mean total exposure.

Orchard workers wearing cotton patches and an air sampler while spraying captan were monitored for the presence of a captan metabolite in their urine[30]. Skin exposure clearly explained urine levels when it was estimated from captan on patches above the ankles and on the neck, despite the fact that the largest amounts were on patches on the wrist and forehead. This indicated that more attention should be paid to the skin areas thought to be most permeable to a chemical, instead of estimating total skin exposure, and that emphasis should not be put on areas with highest exposure only. In certain parts of the body skin is highly permeable, for example in the genital area exposure can result in a 50 times greater absorption[31]. Sweat on skin can also lead to increased absorption of pesticides[32]. In the US, workers' exposure to chlorpyrifos was measured externally for different job types[33]. The absorbed dose derived from exposure varied highly, depending on the job. Forty four percent of workers received higher exposures through their skin than via inhalation indicating that skin is a significant exposure route.

The inhaled exposure can also be influenced by the equipment used. Hydraulic sprayers produce droplets with a mean diameter predominantly above 10-15 micrometers (μm)[34]. These are deposited in the nose or throat[35]. Mist-blowers produce mists that contain a higher percentage of droplets of around 15 μm compared to hydraulic sprayers[36]; these enter the bronchi and so are potentially more dangerous[37]. Due to evaporation droplets in spray drift may be smaller and more easily respired. Evaporation increases with atmospheric pressure[38]. Spray can also be absorbed by breathing through the mouth[39].

## Modelling of workers' exposure

Policies and approaches for assessment of exposures in Europe vary between countries[40]. Most countries prefer measured data, when available and of good quality, over model estimates. However, in the EU, the operator exposure likely to arise under specified conditions of use can be estimated using a model, and where this is not available or if the AOEL may be exceeded, actual exposure data must be reported. Estimates are made for unprotected workers and workers wearing effective protective equipment according to label directions[41].

In the US, the Pesticide Handler Exposure Database (PHED)[42] has empirical data for over 2,000 monitored exposure events that can be used to predict exposure under a range of scenarios. Various types of hazard and risk can be assessed together as in the Evaluation System for Pesticides used in the Netherlands[43]. The UK regulator uses the UK Predictive Operator Exposure Model (UK POEM) and a model has also been developed by the German regulator, BBA[44,45]. The European predictive operator exposure model (EUROPOEM) was developed to include a wider range of scenarios than currently available in POEM, particularly those appropriate to southern Europe[46,47].

## Challenges to risk assessment

### *Inadequate exposure data*

The accuracy of exposure models depends strongly on the exposure data used and on assumptions made regarding spraying equipment, climatic conditions and worker protection. However, data on skin exposure in particular is often lacking since this is rarely part of routine exposure assessment at the workplace. A study of the EU EUROPOEM model applied to greenhouse workers[48] found that the exposures estimated using this model were significantly lower than the measured values[49]. Exposures levels depend on many factors such as the crop being grown or the agricultural conditions and so when using models for a particular scenario it is important to known whether data are comparable.

### *Uncertainties in safety limits*

The AOEL is derived from the NOAEL. However, there are uncertainties both in the estimation of the NOAEL and in the derivation of the AOELs. For example, around 35 toxicological end points may be examined and the dose which causes no adverse effects in test animals deemed to be the NOAEL. It is entirely possible that this dose is causing subtle effects not observed and which will have adverse effects on the exposed animal. In addition, dividing the NOAEL by a safety factor of 100 to obtain the AOEL may not be sufficient[50].

### *Multiple and cumulative exposures*

Cumulative exposures to the same pesticide and multiple exposure to pesticides with a similar mechanism of action should be considered. Risks from the occupational exposure to pesticides are assessed for each active ingredient individually, while in the field workers may be exposed to many active ingredients. Biological markers can contribute to improve exposure assessment[51].

### *High risk groups*

It is necessary to identify subgroups of workers who are particularly at risk from pesticide exposures. Smallholders, and plantation and migrant workers in tropical regions are at particular risk. The distribution of risk among workers differs between countries and is likely to be much higher in developing countries. In Southern India 24% of the farmers reported some health problem due to pesticides, while in Zimbabwe 56% of small-scale cotton farmers reported pesticide-related health problems[52]. Regulators need to identify factors that increase risks.

## Lack of developing country risk assessment

A major problem is the fact that acutely toxic pesticides are used in countries where no proper risk assessments have been carried out. The most hazardous pesticides (certain organophosphates and carbamates, endosulfan, paraquat) are not restricted or banned in many countries and continue to cause acute poisonings in many regions, such as in South America[53]. The risk resulting from an exposure is characterized by the margin of exposure: NOAEL divided by the estimated daily exposure. Even in the US for paraquat the dermal margins of exposure of workers using low-pressure sprayers and of backpack applicators were 'unacceptable' and the practicality of additional personal protective equipment required to reduce the health risks was a matter of concern[54].

## Monitoring required

A serious deficiency in risk assessment regarding workers' exposure is that periodic monitoring is not provided by legislation. Such monitoring would enable a continuous reassessment of the risks to workers and such studies of workers' exposure in the field need to be based on a sufficiently large group as exposure varies considerably between different workers[55].

Anyone aiming to reduce the risks of pesticides, particularly in developing countries where workers are generally at a greater risk, needs to answer the following questions[56]: What are the major factors that contribute to the risk? What are the inherent toxic properties of the pesticides concerned? What are the exposure patterns under conditions of use? What level of risk is acceptable? Who is responsible for addressing the risks?

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