HAZARDS TO AND PROTECTION OF INDIVIDUALS WHO MIX OR APPLY PESTICIDES

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Man is often subjected to relatively high levels of pesticide compounds when he is actively engaged in pest control operations or working directly with the compounds in formulating plants. Experience has shown that if proper precautionary measures and directions are followed, even the more toxic compounds can be handled safely. Although illnesses and even deaths from pesticides occur each year in the United States, it should be pointed out that most of these cases are caused by carelessness or by accident.

The more extensively used modern synthetic insecticides are the organophosphorus, chlorinated hydrocarbon, and carbamate compounds. Generally, the acute toxicity of the organophosphorus group is somewhat greater than that of the chlorinated hydrocarbon or the carbamate compounds. However, the chlorinated hydrocarbon compounds, due to their greater stability, present more of a residue problem. The estimation of hazard to workers who come in contact with pesticides is based primarily on the observed acute dermal, and to a less extent oral, toxicity of these compounds to experimental animals. Where it is available, use experience is considered. The estimated relative acute toxic hazard to spraymen for a number of pesticides can be seen in the table. The classification into toxicity groups is both approximate and relative. It should be noted that these toxicity categories are not related to specific categories spelled out for label requirements.

Much of the safety in relation to pesticides rests on the user or applicator of the compounds. If he is knowledgeable concerning pesticides and understands the importance of taking proper precautions, he can do much to insure the safety of himself and others. This also applies to workers involved in the manufacture and formulation of toxic compounds. Their contact is usually with the more concentrated forms of pesticides; therefore, they should be especially aware of the need for protecting themselves from exposure. Thus, an important adjunct to safety in relation to pesticides is education, not only of supervisory personnel but also of those individuals who actually handle the materials.

There are several very important indirect ways of protecting the worker such as providing education and medical supervision, stressing the

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importance of personal hygiene and cleanliness, the importance of not being careless, and pointing out the need for reading and following directions on the pesticide label. However, these topics will be covered by other presentations on this program. The main purpose of this presentation is to discuss the more direct protection of the various routes of entry of pesticide into the body. Protection of these routes means prevention of exposure and prevention of exposure is undoubtedly the best insurance against poisoning.

ROUTES OF ENTRY

There are four routes of entry of pesticide compounds into the body: (1) dermal, (2) respiratory, (3) oral, and (4) through cuts or abrasions in the skin.

DERMAL ROUTE

The dermal route is considered to be the most important route of entry into the body during most exposure situations in the field and probably plays an important part in exposure of workers in formulating plants. This route is one that has undoubtedly been responsible for a great many poisonings of workers, especially from the more toxic organophosphorus compounds.

In research studies we have measured the potential exposure of several hundred pesticide applicators, and the results indicate that over 97% of the pesticide to which the body is subjected during most exposure situations, and especially to applicators of liquid sprays, is deposited on the skin. It should be understood that any given amount of pesticide is more rapidly and more completely absorbed by the oral or respiratory routes. However, absorption of pesticides by these two routes is probably too small a fraction of the total potential exposure to be considered the main factor in most poisoning cases of workers in the field.

The importance of protecting specific body areas has not been clearly defined in the past. This is because the rate of absorption of different compounds through human skin is difficult to measure with any degree of accuracy. The most useful and probably most accurate estimations or measurements on the percutaneous penetration of pesticides in man which have been accomplished thus far have been made by Maibach and Feldman. 1/ Using radioactive labeled pesticides they were able to determine approximately what fraction of an applied dose would be absorbed through the skin. In this way they not only compared the degree of dermal absorption for certain pesticides but also compared absorption of a single pesticide for different parts of the human body. The results obtained indicate that sufficient importance may not have been attached to protection of certain body areas. In checking dermal penetration of parathion at different body areas these researchers found that the area of greatest absorption on man is the scrotum where approximately 100% of an applied dose was absorbed. The possibility of pesticide on this body area being

completely absorbed is a very important point and emphasizes the need for increased concern about protection of the area. Of utmost importance would be the need for extreme caution in order to avoid spillage of highly toxic liquid pesticide onto the scrotum.

Although cloth coveralls or trousers provide a reasonable amount of protection where contamination does not easily penetrate clothing, the wearing of waterproof trousers provides the best protection for the lower trunk and leg areas and is especially recommended in work situations where there is a chance of liquid spillage, soaking by continued contact with more dilute liquid sprays, or penetration of clothing through **excessive** contact with dry pesticides. In formulating plants where the main outer protective garment is usually cotton coveralls, workers should be required to wear waterproof aprons, especially if they are on duty at bagging or mixing stations where there is often considerable contamination down the front of the clothing with relatively concentrated wettable powder formulations. Fortunately, many plants require the use of aprons. Even when the waterproof apron is used it is very important that the worker change to freshly laundered clothing each day in order to prevent contamination of the scrotum or other skin areas. Needless to say, use of clean clothing and daily bathing in an effort to avoid excess dermal absorption are essential in any type of exposure situation.

Protection of the upper trunk and arms from contamination by toxic pesticides is important, especially under conditions where heavy spray drift may thoroughly wet cloth shirts, coveralls, and underclothing or where concentrated dry pesticides come in contact with clothing and skin in formulating plants. Our studies have shown that the greatest potential contamination of spraymen in this general body area is the upper back, shoulders, and forearms of workers operating equipment which propels spray up into the air where it is more subject to drift. Under these conditions a waterproof jacket or raincoat provides the best protection for this general body area. This gear is usually worn during cooler conditions, but as the temperature rises and the clothing becomes unbearably hot to wear, workers tend to discard them and work with much less protection--perhaps only a short-sleeved T-shirt-type undershirt on the upper trunk area. Under such conditions workers should be encouraged to at least wear a long-sleeved cloth jacket that will not be easily penetrated by pesticide, and preferably one that can be properly washed.

The wearing of long-sleeved heavy grade "GI" cotton shirts or coveralls as outer clothing during hot weather, often with no underclothing, is popular with many applicators even though this is not a recommended practice. Fortunately, these items of outer clothing provide a reasonable amount of protection where spray drift is light with very fine droplets that do not wet through to the skin. Under such conditions the clothing should be changed and laundered daily. If clothing used during spraying such as shirts, jackets, or coveralls are merely hung up to dry after work and used repeatedly, as is often the practice, it doesn't take

long for the pesticide material to work through where it will make contact with underclothes or skin.

In selecting protective clothing for workers it is important to take into consideration the comfort of the individual when he wears such items. The conventional black or dark green rubberized or plastic waterproof jackets in common use during past years are considered by many applicators to be uncomfortable to wear not only because of greater heat absorption but also because they may be of heavy grade material and not very flexible. During recent years, however, several jackets and jacket-trouser combinations that are lighter in color and weight have been available. Although less durable, they are less costly to replace. Nevertheless, there is still considerable discomfort in wearing any waterproof clothing during hot weather because of the trapping of body heat.

Observations of pesticide applicators have indicated that although waterproof clothing items, and especially jackets, are usually carried by the workers, or readily available to them, they usually will not don the clothing until drift of pesticide increases to the point where they feel protection is necessary. Unfortunately, by this time there is often considerable contamination of skin and clothing. The covering of contaminated skin areas by waterproof clothing may create conditions under which dermal absorption may be increased. This may be more important during hot weather where high temperatures and perspiration are involved. Whether or not there would be less absorption under these conditions than if the clothing were left off entirely depends upon the potential exposure which might occur after the worker puts on the clothing. Maibach and Feldman 1/ found that covering up (occlusion) of contaminated skin with thin plastic wrap material caused approximately a four-fold increase in absorption of parathion. Although the increase of absorption of pesticide by covering contaminated skin with various items of protective clothing is not known, the above occlusion test results are cause to emphasize the need to put on protective gear before the skin has been contaminated to any great degree.

The use of waterproof jackets in pesticide formulating plants is not common and generally not considered a requirement if, as stated earlier, rubber aprons are worn and coveralls are kept clean. It should be noted, however, that in a plant there is more ready access to showers and other means of decontamination, should excess exposure occur, than in the field where applicators work.

Results of the dermal absorption studies noted above indicate that the head-neck area should be given more attention. In this area absorptions of parathion was found to be from 32 to 47% of an applied dose; much more than we would have anticipated and more than at other areas of the body studied with the exception of the armpit and scrotum. When observing either pesticide applicators or workers in formulating plants it is easy to conclude that the face-neck area is less protected than most other parts of the body. Head coverings or caps used in formulating plants are often made of material that allows easy penetration of pesticide onto the scalp. The headgear may have no bill or brim which would provide some

added protection to the face-neck area, especially from pesticide material which drifts downward.

Protection from downward drift is especially important during application of liquid sprays. The headgear most commonly used by pesticide applicators is the billed cap which provides some protection for the face but very little for the remainder of the head-neck area other than the scalp. The conventional "Sou'wester" rain hat, often used when heavy downward drift occurs, does not provide exceptionally good protection for the face and sides of the neck. This is because of the narrow brim in all areas except at the back of the neck. Metal or fiber "hard hats" are also used to some extent; however, most have too narrow a brim to provide adequate protection. "Hard hats" which allow circulation of air over the head under the hat should not be used where exposure is to toxic dusts.

Our studies have shown that the greatest protection from downward drift of pesticides is afforded by some type of wide-brimmed hat, preferably made of water-repellent material. Waterproof hats, other than the "Sou'wester," were not readily available at that time. However, one is now available which is waterproof and also has a wide brim that affords good protection of the face-neck area. This type of hat should be recommended for use by all applicators who may be subjected to downward drift of pesticides.

Of particular interest in relation to exposure of the head-neck area is the finding by Maibach and Feldman[1] that absorption of parathion is relatively efficient (47% of applied dose) in the ear canal. Exposure in this area could occur through drift of fine pesticide mists or dusts or by digging in the ear with the tip of a contaminated finger. Of particular importance is the potential for drift into the ear of concentrated dry formulations of toxic compounds in the formulating plant.

It is of importance to note that wearing goggles and respirators provides considerable protection to the face.

Although a statement suggesting the use of goggles can be found on certain pesticide labels, they are rarely worn except by pilots who apply pesticides by aircraft. Questioning of pilots has revealed that they wear goggles not only to prevent poisoning and to keep wind out of the eyes but also to prevent certain organophosphorus pesticides that are direct inhibitors of cholinesterase from causing miosis. This is understandable because it has been shown that unilateral contamination of the eye with TEPP may cause pilots to inadequately judge distance.[2] The incoordination which may accompany this could be a serious threat to safety.

The hands are often the body area having the highest exposure to pesticides and they have a greater chance of coming in contact with the more concentrate formulations. They are also more subject to cuts or abrasions, which will be discussed later.

High potential exposure to the hands brings attention to the need for wearing gloves. Some people who have worked with pesticides feel it is better not to wear gloves than to wear gloves that are contaminated on the inside; something which invariably occurs to some degree. Our research concerning the use of protective gloves indicates that, unless there is gross contamination of the inside of the gloves, the potential exposure is less when wearing gloves than when not wearing them. If gloves are kept clean on the inside there is very little doubt concerning the value of their use when handling pesticides. Unlined rubber gauntlet gloves provide the best protection because the gauntlet covers the wrist area not normally covered by the jacket sleeve and they can be turned wrong side out for proper cleansing of the unlined inside surface.

Waterproof shoes or boots should be worn when handling or applying pesticides on a large scale. During liquid spray operations the ground cover of weeds, grasses, or other plants invariably becomes wet with dilute pesticide regardless of whether or not it is the target of the application. Shoes quickly become contaminated when walking through such plant growth. When leather shoes become wet with spray material they have a tendency to become cracked and dried out to the extent that pesticide easily penetrates through to the sock or foot. Both leather and canvas shoes absorb chemicals and may hold them in contact with the wearer. Boots should be washed and dried thoroughly, inside and out, as frequently as needed to remove any pesticide contaminant.

Workers in pesticide formulating plants should wear waterproof boots. Coverall pant legs should be worn outside the boot tops to prevent sifting of dry concentrated pesticide into the footwear.

RESPIRATORY ROUTE

Protection of the respiratory route is especially important where toxic dusts and vapors or very small spray droplets are prevalent, or where application is in confined spaces. Extremely fine particles and droplets found in dusts and mists are much more easily drawn into the respiratory system than the larger droplets formed by most conventional dilute spray machines. Our tests have shown that when operating an 8X (eight times the normal dilute concentration) concentrate airblast machine in fruit orchards the potential respiratory exposure is nearlx 3 times greater than when operating the conventional dilute machine.-)

Respiratory protection for most types of application can be provided by use of cartridge-type respirators or, in certain cases, gas masks with special cannisters which have greater adsorbent capacity than the cartridges. Applicator pilots who risk the possibility of flying through drift of fine droplets or dusts should use a face mask equipped with a filter cannister and attached either to their belt or to the inside of the cockpit. When fumigating or applying highly toxic pesticides in confined spaces it is advisable to use a respirator with a special compressed air supply ank so that none of the contaminated ambient air is inhaled.

Proper care of respirators is very important to the protection of the workers. The rubber face-piece becomes hardened and the head straps lose their elasticity with age and exposure to heat and sunlight. These conditions lead to poor fit and allow leakage around the face-piece. Two of the more common offenses in the care of respirators that we have observed are (1) failing to occasionally wash the face-piece with soap and water and (2) neglecting to change the filter cartridges or cannisters regularly. Washing of the face-piece of a cartridge-type respirator should not be attempted while the cartridges are in place as moisture may contact the activated charcoal filter material and **reduce its effective-** ness in adsorption and absorption of pesticides. Solvents should not be used as a cleaner for they may damage certain parts of the respirator. The general recommendation is that cartridges should be changed after 8 hours of continuous exposure. In most application situations this leaves much up to the individual worker to keep a record of his respirator exposure time. In a formulating plant where hours of exposure are more regular this is more easily controlled under the guidance of a foreman. Under conditions of intense exposure the useful life of the cartridge is much shorter. Thus, if the breathing seems hampered, **or if** the odor of pesticide is detected, the filter cartridges should be changed immediately. If the outer filter pads are separate removable units they should be changed more frequently than the cartridges.

During discussions of the respiratory route of entry into the body the question is often raised concerning the hazard of smoking pesticide-contaminated cigarettes. We have found it difficult to measure such potential exposure with any great degree of accuracy. The technique we have utilized thus far involves subjecting the cigarettes to normal handling through the process of removing them from the pack and placing them in the mouth, lighting them, and smoking one-half the cigarette. The remainder of the cigarette is then analyzed for pesticide content. The values obtained are based on the assumption that pesticide on the cigarette will be volatilized before being broken down by burning and that none of the volatile or particulate pesticide would be trapped in the butt end of the cigarette. In observing smoking by **workers it was** noted that the area of greatest contamination of the cigarette was far enough from the butt end to allow burning of the contaminated area in most cases.

In studies of cigarette contamination by spraymen applying endrin in orchards, the potential exposure through smoking during application operations was calculated to be not more than 0.002 mg per cigarette, even when the cigarettes were handled with hands wet with the dilute spray.[4] In later studies[5] involving spraymen applying parathion to apple orchards by airbiast machines, from 0.003 to 0.005 mg of parathion per cigarette could be recovered where they were handled with hands that **were** contaminated but dry. When handled with hands that were wet enough with dilute spray to leave moist spots on the cigarette paper from 0.020 to 0.050 mg could be found. In a controlled study designed to determine what might be the maximum contamination of cigarettes through such

handling, hands were dipped in 45% emulsifiable concentrate parathion, the hands wiped off lightly on the trousers, and the cigarettes were handled to simulate smoking. The highest value found was 0.235 mg per cigarette.

Even though values for potential respiratory exposure through smoking contaminated cigarettes may not appear to reflect any great hazard, two important points must be kept in mind: (1) Pesticide entering by the respiratory route is practically 100% absorbed, and (2) There is no assurance that a more toxic breakdown product will not be formed and inhaled as the high temperature of a burning cigarette reaches the contaminated areas rather than complete destruction of the compound by burning. For example, in the case of parathion the oxidation product, paraoxon, is estimated to be much more toxic than the parent compound, possibly 100 to 500 times more toxic. This could be an important factor as far as hazard is concerned and emphasizes the need for recommending washing of hands and face before smoking.

ORAL ROUTE

There has been little experimental work conducted to define the magnitude of oral exposure. We are studying techniques at the present time. Analysis of saliva samples of exposed individuals appears to give some indication of contamination.

The most serious oral exposure may be brought about by splashing of liquid concentrate into the mouth while pouring and measuring pesticides. Contamination may also occur through licking the lips, by rubbing the mouth with contaminated arms or hands, by careless actions such as attempting to blow out clogged spray nozzles with the mouth, or by eating or drinking with contaminated hands. Workers should wash hands and face before eating, drinking, or smoking.

ENTRY TRHOUGH CUTS OR ABRASIONS

This route of entry is one that may not have received enough attention in the past. Cuts and abrasions occur most frequently on the hands, and unfortunately the hands are the body area most often in contact with the more concentrate forms of pesticides.

Any break in the skin may allow a more direct route of entry into the blood stream. Even if the outer layer of dead cells (strateum corneum) of the skin is removed by scratching or scuffing the result may be a potential for increased absorption at that site as this layer of cells is considered the main barrier against chemicals. Maibach and Feldman 1/ found that when most of these cells ware removed by abrading through repeated application and removal of sticky tape, the absorption of parathion applied to the forearm could be increased more than 8-fold. There have been poisoning cases suspected as having been a result of entry through cuts or abrasions. However, there has not been enough evidence to definitely prove that this route played the major part in the illnesses.

DISCUSSION

Regardless of how specifically the measures for protection of workers from exposure to toxic pesticides may be stated for any particular situation, people who work with such compounds must realize that there is some element of risk involved. Accidents occur, even among workers who are careful. In case of accidental gross contamination of skin with a highly toxic compound every effort must be made to cleanse the contaminated area as quickly and as thoroughly as possible. The best recommendation at present is the use of plenty of soap and water. If pesticide gets in the eyes they should be thoroughly flushed with water for at least five minutes. If a person should feel ill while working with pesticides he should stop work at once and get medical attention. If his illness is diagnosed as being caused by a pesticide he should not return to work until a physician advises that it is safe to do so.

References

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