PHOSPHATE USE IN CALIFORNIA MOSQUITO CONTROL

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Operational use of the organo-phosphate insecticides in California began in three mosquito districts in 1952, following developmental work by C. M. Gjullin in cooperation with the Kern Mosquito Abatement District. These materials were resorted to principally because of the increase in mosquito resistance to the chlorinated hydrocarbons, and because of the emergency situation created by the mosquito-borne encephalitis outbreak of that year.

EPN was the material applied that first year, and the principal phosphate used in 1953, when two additional districts adopted it. Some use of malathion was also made in 1953 by the Kern District in urban areas. Unfortunately, the available supply of emulsifiable EPN was exhausted that year, with the result that parathion and malathion have since been the most widely used phosphates.

It is interesting to note here that there remained an ample supply of wettable-powder EPN, but, with a few exceptions, the control agencies were not in a position to modify their equipment to handle it, and as a result switched insecticides when the manufacturers of EPN could not be persuaded to produce the emulsifiable concentrate. In view of the fact that over 120,000 pounds of malathion and parathion have since been applied for mosquito control in California alone, we cannot help but wonder if the basic producers might not find it worthwhile to reevaluate the potential market in the field of mosquito control.

In 1954, seven more districts adopted the phosphates, and four additional districts got on the band wagon during the season just completed, making a total of sixteen districts using the materials in operational quantities during 1955.

The comparisons of the extent of this use in table 1, are based upon 1954 figures compiled by Dr. W. D. Murray, of the Delta M.A.D., and 1955 data compiled by the author from a questionnaire sent to all California control agencies this winter.

TABLE 1.—Comparison of California phosphate use for mosquito control, 1954–55

	1954	1955
Agencies using phosphates	12	16
Agencies using malathion	10	12
Agencies using parathion	7	8
Agencies using both above	5	4
Agencies using EPN	2	none
Agencies making preliminary tests of malathion or parathion		3
Malathion use	20,756 lbs. 56,392 acres	51,230 lbs. 111,036 acres
Parathion use	15,454 lbs. 177,666 acres	33,716 lbs. 355,386 acres
EPN use	4,939 lbs. 50,138 acres	none
Total phosphate use	41,149 lbs. 284,196 acres	84,926 lbs. 466,422 acres

In addition to the chemicals listed, chlorthion was tested by many of the districts in 1954, or 1955, and while its results approached those of parathion and malathion, its comparatively high cost has precluded its use on an operational basis.

These materials were applied by a variety of methods, as summarized in Table 2. Virtually all of the spray applications were in the form of water emulsions, mixed from concentrates containing two or four pounds of parathion, or five or eight pounds of malathion per gallon.

Of more interest to the practicing mosquito control worker than the foregoing quantitative statistics is information about the results obtained, costs, and the techniques developed for the safe handling of these highly toxic materials.

As to results, we would not be using these insecticides if they were not highly

TABLE 2.—Methods of application of phosphate insecticides in California mosquito control during 1955

Larvicide:	Parathion	Malathion	Totals
	lbs.	lbs.	lbs.
Airplane Spray	21,598	17,850	40,489
Power spray or Mist-blower	3,953	17,159	21,112
Hand-spray	7,154	2,793	9,947
Granular, by air	20	2,410	2,430
Granular, by hand		9,067	9,067
Adulticide:			
Thermal aerosol		600	600
Air-spray	991	131	1,122
Ground spray		1,200	1,200

efficient. Of the sixteen districts which use them, thirteen report consistent 100 percent larval kills on all species with either material, one reports 95 percent results, and two, spotty results. In all three of these latter districts, malathion is the only phosphate used, but it is, of course, highly possible, in view of the excellent results in the majority of cases, that some factor other than the material is at fault here. All sixteen, including those which have made wide use of them for as long as four full seasons, report no apparent development of resistance to the phosphates in the mosquito populations.

While these materials are applied primarily as larvicides, excellent incidental kills of adult mosquitoes have been noted from the beginning. As a result, in cases where a mosquito source in an isolated area is discovered when the adults are already emerging, but before they have moved out of the area, many districts have adopted the practice of making standard larvicidal applications of phosphates, by plane or ground power spray, to kill both these adults and the remaining larvae.

With the clearance of the use of low concentrations of malathion in urban areas by the California State Department of Public Health's Bureau of Adult Health in the spring of 1955, this material began to be used more and more extensively as an adulticide, applied by thermal aerosol rigs as well as by small-particle mist-blowers. Results of this use have shown a marked improvement over materials previously used in this manner.

Costs vary from very low for parathion, to rather high for malathion. Based on prices paid by the author's district, which are believed to be consistent with those of the rest of the state, and at normal dosage rates, parathion costs about twenty-six cents per acre, while malathion runs as high as ninety-six cents per acre. Dosage rates and formulations of DDT in common use vary so widely that no general comparison with the per acre cost of this material is practical. In the author's district, where 1 lb./acre of DDT in any formulation is the smallest dose which gives reasonable kills, but where we are equipped to formulate our own 25 percent DDT concentrates at a cost of about eighty cents per gallon, DDT costs forty cents per acre. That places the cost of DDT, in our case, at almost twice the cost of parathion, and not quite half that of malathion. Of course, it cannot be emphasized too strongly that no insecticide is cheap if it does not deliver consistently good kills.

Why then, if parathion is so effective and so inexpensive, has it not been adopted as the universal insecticide for mosquito control? The answer, of course, is its extreme toxicity to warm blooded animals. This leads us to the final subject, and the one which, I am sure, is of paramount importance to those mosquito control workers who foresee a future necessity for using the phosphates, that of how these materials may be handled and applied so as to minimize the danger to humans and other animals.

Using phosphate insecticides for mosquito control may well be likened to parachute jumping. Neither are sports to be indulged in for week-end entertainment, but the pilot who is wearing a parachute when his engine quits, feels no greater relief than does the mosquito-chaser who has the phosphates to rely upon when his DDT fails him. And to carry the analogy a step further, neither parachute-jumping nor phosphate-handling are activities in which you can learn by trial-and-error. You have to be right the first time, because your second chance may be granted only by Saint Peter. That prospect may sound rather grim, but I doubt that it would stop you from bailing out of a damaged plane, nor should it deter you from using these excellent insecticides if the need arises. Others have done both, with no ill effects, and there is no reason why you cannot as well.

The smart pilot, while he does not practice jumping, does learn to strap his chute on correctly, locates his rip-cord handle, and may even practice tumbling to learn to land without injury.

What I propose to do is tell you what we have learned in using the phosphates, about fastening those buckles, finding that rip-cord, and how to land on your feet if you do have an accident.

During the past four years, mosquito control workers in California have handled over seventy-five tons of the phosphates without a single fatality or a major injury. (The weight given is that of the actual toxic ingredients, not that of concentrates or diluted mixtures.) This has not happened by chance, but through carefully planned and rigidly enforced procedures for handling and applying these insecticides.

It should be pointed out here that these procedures vary slightly from district to district, and according to insecticide and method of application. Malathion is laboratory rated as relatively low in toxicity to mammals and is therefore used, by some agencies, with only the normal precautions afforded any insecticide. Other districts feel that, especially in the concentrated form, malathion is as hazardous as parathion, and so treat it accordingly.

Under California Bureau of Chemistry regulations, the maximum dosage allowed for mosquito control is .1 lb./acre of parathion, and .5 lb./acre of malathion. Most Districts have found that doses as low is .075 lb./acre of parathion and .3 lb./acre of malathion, give excellent results.

Since parathion is on the official list of hazardous chemicals, a permit from the County Agricultural Commissioner is required for its purchase and use. While for agricultural applications individual permits are required for each spray job, most mosquito districts receive blanket permits for periods as long as an entire season.

As has been pointed out by Dr. Radeleff, these chemicals at such dilutions are not likely to be harmful. It is, therefore, the opinion of most workers that protection of the public and of livestock, is no great difficulty, since they are normally exposed only to the diluted materials and at infrequent intervals. The only problems involved are those of maintaining constant rates of application and dilution, avoiding accidental over-dosage, and eliminating the possibility of contact with the concentrates.

The maintenance of constant dilutions and application rates is, of course, a routine problem, overcome by equipment design and operator training, which must be solved for efficient operation regardless of the material used.

Accidental over-dosages are minimized by the same means, but when they do occur, through machinery failure, etc., a routine emergency procedure of decontamination and/or quarantine of the area, as well as treatment of exposed persons or livestock must be previously explained to, and thoroughly understood by, the operator.

The final problem is solved by allowing no phosphate concentrates to be removed from a designated, protected area, or if it is necessary for refill loads to be carried on the spray trucks, requiring that these be kept in a locked, leak-proof container, and setting up loading procedures which insure against spillage of concentrates. Disposal of empty drums and cans is another phase of this problem, with procedures usually outlined by the supplier or by regulatory agencies.

The major hazard, then, is to our own personnel, who may receive daily light exposures from diluted sprays over a sufficient period to cause illness, or who are exposed to the acute poisoning of small amounts of concentrates.

To minimize both types of exposure, as well as their effects, administrative planning and employee education again are the keys. Protective equipment and procedures must be provided by management, and the operators trained to use them fully. A rigid set of safety regulations is necessary, as is their strict enforcement.

Examples of equipment changes and additions which have been employed to this end are the rubber gloves, goggles, and respirators employed in repackaging concentrates into one tank-charge loads, usually in unbreakable plastic bottles, the special siphon equipment developed for mixing correct amounts of concentrate with the diluent as the latter is being pumped to the planes, the partitioned lock-boxes on spray-trucks for carrying concentrates, the soap and towels provided at each handling point and on each vehicle using phosphates, and the redesign and continuous maintenance of spraying equipment, to minimize operator exposure to drifting or leaking spray material.

Other administrative steps which should be taken are the alerting and briefing of local doctors as to the materials being used, so that they may make a special study of symptoms and treatments. Prescriptions may be obtained from them for the specific antidote, atropine, which operators may carry for emergencies. It is important that the manager, and through him the operators, receive careful instructions in when and how to use the antidote, since it is as poisonous as the phosphates themselves.

Blood cholinesterase level tests should be provided prior to first use of the chemicals and following any acute exposure or exhibition of symptoms, and may be provided on a routine monthly basis during the spraying season, which, among the phosphate-using Districts, averaged six months each year, with highs of eight months.

One of the reasons the author was requested to prepare this paper was that his district has had such tests made monthly on all exposed personnel (entomologist, four pilots, and aircraft mechanic) for the past two years, and it was felt that such a chronological picture of these enzyme levels might be of interest. However, on checking them, it was found that there was really not much to be shown, in that these levels ran steadily along through both years, with virtually no deviation from the pre-determined normals. In the two instances where pilots exhibited what might have been phosphate poisoning symptoms, extra blood tests were run, which reassured us that the cholinesterase level was normal, and, in both instances, the symptoms developed into obvious cases of virus infections. However, the fact that we have not had to use the information provided by these tests is no indication that we will discontinue them, any more than the fact that we might not have had a flat for two years would lead us to discard all our spare tires. If chronic poisoning begins to build up, we will know it in time to take steps to remedy the situation, and in cases of acute poisoning, the doctors will know the extent of the damage immediately, and therefore the amount and kind of treatment necessary.

Local veterinarians should be briefed and provided with copies of Dr. Radeleff's bulletin and other pertinent literature, so that they can recognize and treat phosphate poisoning in livestock. From the mosquito district standpoint, it is of even more importance that they be able to determine accurately when questionable cases are *not* caused by the phosphates, since this may save us the expense of purchasing beef which we are not allowed to eat.

Finally, and most important, is the education of operators and enforcement of regulations. These are the men who apply and are in contact with the materials and who will make or break the operation both from the mosquito control and the safety standpoints.

In addition to individual and class training sessions, most districts supply the operators with printed regulations, which cover, in detail, such subjects as poisoning symptoms, emergency treatments, routine cleanliness, step-by-step procedures for handling concentrates, applying sprays, cleaning and maintaining equipment, disposing of concentrate containers, etc. No attempt will be made here to cover the full information contained in these, but copies may be obtained from the Merced District, as well as, I am sure from the Kern, Delta, and Turlock Districts, among others.

One thing which the regulations employed by the various districts have in common is the concluding statement, underlined and in capital letters, which reads, *"Anyone not following these instructions will be subject to immediate discharge."* This penalty is strictly adhered to and ex-employees who have been subjected to it are considered, by all involved, to be fortunate to be unemployed but alive.

If the foregoing makes it appear that we are afraid of these materials, it is only because we are. And we will, I hope, continue to be frightened by them, because only by a constant respect for them, and vigilance in their use, will we continue alive and healthy to enjoy the real benefits which accrue from their application.

It is the author's belief that we will continue to be extremely respectful of these chemicals, and lean over backwards in taking precautions in their use, and that the full utilization of the phosphates in California mosquito control is only beginning, because they are extremely efficient mosquito killers.

Lest the impression be left that we feel that chemical control is the ultimate answer, it is necessary here at least to mention the far more important phase of mosquito control, that of source reduction through drainage and water management. To get back to our parachute, the best chute in the world is no substitute for good preventative maintenance on the airplane.