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Initial Field Studies in Upper Volta with Dichlorvos Residual Fumigant as a Malaria Eradication Technique*

3. Toxicological Evaluation

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The residual fumigant technique involving the use of dichlorvos in the solid dispenser formulation employed in the study reported in this paper appears to offer no hazard to the occupants of houses treated at the rate of one dispenser per 500 cubic feet (14 m³) in so far as dichlorvos vapour toxicity is concerned. Even the maximum dosage rate tested (one dispenser per 60 cubic feet (1.7 m³) or 28 dispensers in a two-room house) did not produce observable effects on the occupants of the houses. This maximum rate far exceeds that necessary for malaria eradication operations, thereby affording an additional safety factor.

The general plan of work followed and the overall experiment with dichlorvos as a residual fumigant for malaria control in the test village of Wakara, Upper Volta, have been described in the first paper in this series.[4]

PROCEDURE

In conducting the toxicological studies, physical examinations were made and cholinesterase and haemoglobin levels were determined for all subjects before and after exposure to the dichlorvos vapours. A modified micro-Michel method[5] was used for cholinesterase determinations, and the cyanomethaemoglobin method for determining haemoglobin. Also, seven weeks after the initial treatment with dichlorvos was begun, haematocrit data on children in both the treated and untreated villages were obtained.

The subjects included 19 inhabitants selected at random in the treated village, and 25 occupants of six houses that were to be studied intensively. Since three of the intensive-study houses never received treatment at a rate higher than that for the village in general, the data on the 10 occupants of these houses have been included (Table 1) with those for the 19 people selected randomly. Of these 29 individuals, 17 were males and 12 were females. By age, among the males four were under 6 years old, two were between 6 and 20 years, five were in the 21-40-year age-group, and six were between 41 and 64. Among the females, one was less than 6 years old, four were between 6 and 20 years, five between 21 and 40, and two between 41 and 51 years old.

The three intensive-study houses in which the dichlorvos dispensers were progressively increased up to a maximum concentration of one dispenser per 60 cubic feet (1.7 m³), or about nine times the general rate of use in the village, housed a total of eight males and seven females. By age, among the males three were under 6 years of age, two were between 6 and 20, two were between 21 and 40, and one was 43 years old; and among the females, three were under 6 years, one was 13, and three were between 23 and 37 years old. None of these people showed any effects whatsoever from the exposure to

* These studies were accomplished as part of a contractual agreement between the Communicable Disease Center, Savannah, Ga., and the Agency for International Development.

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[4] See the article by Quarterman et al. on page 231 of this issue.

[5] Hamblin, D. O. & Marchand, H. F. (1951) *Cholinesterase tests and their applicability in the field*, New York, American Cyanamid Company.

dichlorvos. While the numbers of individuals in each age- and sex-group were small, it is believed that the total number represented an adequate sample.

The village was treated initially during the period from 26 June to 5 July at the rate of one dispenser per approximately 750 cubic feet (21 m^3), with an over-all range of from one dispenser per 500 cubic feet to one per 1000 cubic feet (approximately 14-28 m^3). Subsequent treatments of the village were made at the rate of one dispenser per approximately 500 cubic feet.[1]

Chemical evaluation consisted in determining the amount of dichlorvos present in air samples taken from representative houses. Intensive air sampling was done following the initial treatment, especially in the six houses to be studied in detail. In these houses, air samples were obtained once a week, and more frequently following any change in the number of dispensers. In addition, houses selected at random in the village were sampled at varying intervals. Most of the air samples were collected at the 6-foot (1.8-m) level. A small number of samples taken at the 2-foot (0.6-m) level indicated that the air concentrations of dichlorvos vapour at this level ranged from approximately 50% to almost the equivalent of the concentrations at the 6-foot level. These lower values for samples taken at the 2-foot level were reflected in the more erratic biological results obtained with mosquitos exposed at this level.[1] Air samples taken at the 6-foot level early in the morning and late in the afternoon of the same day (29 July) in the same three houses showed that the air concentrations of dichlorvos were approximately twice as high in the morning as in the evening. This might be expected as a result of the usual practice of closing the windows and doors at night and leaving them open during the day. The majority of the air samples taken for use in the toxicological evaluations were taken in the morning, but both midday and afternoon samples were also included.

The occurrence of higher air concentrations of dichlorvos vapour in the mornings, as compared with the afternoons, during the period of the toxicological studies (June-August), was in direct contrast to a reverse situation during preliminary studies in May when hot, dry weather prevailed. At that time, the late afternoon air concentrations of dichlorvos vapour were approximately twice as high as during the early morning. The average daily temperatures inside the houses were approximately 6°F-8°F (3.3°C-4.4°C) higher in May than during the toxicological studies. The higher temperatures during the day apparently caused a sufficiently higher rate of vaporization of the dichlorvos to more than offset the increase in ventilation during the day. With the lower temperatures prevailing during the period of the toxicological studies, the rate of vaporization was apparently not high enough to overcome the increased ventilation of the houses during the day when windows and doors were open.

Air samples were collected and analysed for dichlorvos according to the procedure outlined in Chemical Memorandum No. 7 prepared by the Technical Development Laboratories.[2]

RESULTS

The toxicological evaluation consisted of follow-up physical and haematological examinations of the people selected at the onset of the experiment. The air concentrations of dichlorvos obtained in houses where the number of dispensers was the same as that used in the general treatment of the village are presented in Table 1. This table also presents the cholinesterase values obtained on inhabitants of these houses. Table 2 presents the air concentrations obtained in the houses selected for intensive study, in which the number of dispensers was progressively increased to a maximum of about nine times the number that would normally be used. This table also presents the cholinesterase data of the occupants of these dwellings during this period.

Table 3 presents cholinesterase, haemoglobin and haematocrit data obtained from 15 children under 6 years of age selected at random from the check village and from a further 15 children from the treated village. These children were sampled on 15 August 1961, at which time the children in the treated village had been exposed to dichlorvos for about seven weeks.

In addition to these values, the haemoglobin value was obtained once during the period of highest air concentration on each of the six children under 6 years of age (6 months to 5 years) in the intensive-study houses receiving the highest dosage of dichlorvos. The values ranged from 8.2 to 12.7, or an average of 10.9 for the six. Fourteen haematocrit values obtained from the same children during this period ranged from 24 to 37, or an average of 32. These values were about the same as those for the children sampled at random (see Table 3).

[1] See the article by Mathis et al. on page 237 of this issue.

[2] Unpublished document, 1961.

TABLE 1

AIR CONCENTRATION OF DICHLORVOS IN HOUSES WHERE IT WAS EMPLOYED AT A RATE OF ONE DISPENSER PER 400-1000 CUBIC FEET (11-28 m³), AND BLOOD CHOLINESTERASE VALUES OF PEOPLE LIVING IN THOSE HOUSES

Dates (1961)	Air concentration of dichlorvos (μg/litre) [a]				Cholinesterase activity (ΔpH/hr)						
						Red blood cells			Plasma		
	No. of air samples	Range	Mean	Standard deviation	No. of blood samples	Range	Mean	Standard deviation	Range	Mean	Standard deviation
20-25 June	Prior to dichlorvos treatment				36	0.42-0.80	0.58	0.092	0.44-1.20	0.63	0.141
26 June-5 July	17	0.007-0.059	0.028	0.015	10	0.45-0.64	0.55	0.064	0.49-0.72	0.57	0.084
6-31 July	15	0.008-0.147	0.034	0.035	8	0.51-0.78	0.65	0.093	Samples lost		
1-13 August	8	0.011-0.098	0.052	0.031	30	0.50-0.88	0.64	0.094	0.42-0.95	0.65	0.126

[a] All air samples taken at 6-foot (1.8-m) level.

TABLE 2

AIR CONCENTRATION OF DICHLORVOS IN HOUSES WHERE DICHLORVOS TREATMENT WAS INCREASED AT INTERVALS UP TO A MAXIMUM OF ONE DISPENSER PER 60-88 CUBIC FEET (1.7-2.5 m³), AND BLOOD CHOLINESTERASE VALUES OF PEOPLE LIVING IN THOSE HOUSES IN WAKARA

Dates (1961)	Cubic feet [a] per dispenser	Air concentration of dichlorvos (μg/litre) [b]				Cholinesterase activity (ΔpH/hr)						
							Red blood cells			Plasma		
		No. of air samples	Range	Mean	Standard deviation	No. of blood samples	Range	Mean	Standard deviation	Range	Mean	Standard deviation
20-25 June		Prior to dichlorvos treatment				24	0.45-0.62	0.56	0.048	0.40-0.86	0.62	0.139
26 June-5 July	720-880	17	0.008-0.059	0.022	0.012	15	0.43-0.60	0.53	0.050	0.38-0.86	0.60	0.132
6-31 July	144-360	18	0.017-0.445	0.134	0.103	13	0.48-0.72	0.59	0.071	Samples lost		
1-13 August	60-88	6	0.170-0.840	0.433	0.237	23	0.41-0.80	0.58	0.103	0.40-0.90	0.62	0.151

[a] 100 cubic feet = 2.83 m³. [b] All air samples taken at 6-foot (1.8-m) level.

TABLE 3

CHOLINESTERASE, HAEMOGLOBIN AND HAEMATOCRIT VALUES FOR YOUNG CHILDREN SELECTED AT RANDOM FROM THE DICHLORVOS-TREATED AND THE UNTREATED VILLAGES

Group	Cholinesterase activity (ΔpH/hr)					Haemoglobin			Haematocrit		
	Red blood cells			Plasma							
	No. of blood samples	Range	Mean ± SD	Range	Mean ± SD	No. of blood samples	Range	Mean ± SD	No. of blood samples	Range	Mean ± SD
Sara [a]	9	0.47-0.61	0.55 ± 0.048	0.44-1.13	0.63 ± 0.198	14	8.6-16.0	12.1 ± 2.1	10	28-40	35 ± 3.91
Wakara [b]	11	0.45-0.77	0.61 ± 0.091	0.52-0.85	0.67 ± 0.094	14	7.7-15.7	11.4 ± 1.87	11	26-38	32 ± 4.40

[a] Control village, 15 children: average age, 22.9 months: age range, 4 months to 5 years.
[b] Village treated with dichlorvos, 15 children: average age, 30 months: age range, 4 months to 5 years.

The data presented in these tables and in the foregoing paragraph indicate that the dichlorvos treatment had no significant effect on cholinesterase activity or on haemoglobin and haematocrit levels, even when the number of dispensers was increased about nine times, resulting in air concentrations of dichlorvos as great as 0.84 μg per litre. The slightly lower haemoglobin and haematocrit values observed in the treated village are not statistically significant, as indicated by the fact that the difference in means does not exceed the combined standard deviation. The correlation coefficients (0.08 and 0.28) indicate no relationship of age to haemoglobin level in the two groups shown in Table 3. Any discussion of the reason for the slightly low haemoglobin and haematocrit values for the children in the untreated check village, as well as the others, is beyond the scope of this paper.

The results of this study of the effect of dichlorvos on blood cholinesterase are consistent with those reported earlier by Hayes.[1]

CONCLUSIONS

From the data presented above, it appears that the residual fumigant technique, with dichlorvos in the solid dispenser formulation employed in this experiment, offers no hazard to the occupants of houses treated at the rate of one dispenser per 500 cubic feet (14 m^3), in so far as the dichlorvos vapour toxicity is concerned. Because even the maximum dosage rate tested (one dispenser per 60 cubic feet (1.7 m^3), or 28 dispensers in a two-room house) did not produce observable effects on the occupants of the houses, and because such a high rate of treatment would be both unnecessary and excessively costly, there appears to be an additional factor of safety in the technique.

[1] Hayes, W. J., jr (1961) *Bull. Wld Hlth Org.*, **24**, 629.

RÉSUMÉ

La technique de fumigation par le DDVP présenté sous forme solide ne présente aucun danger pour les occupants des habitations traitées à raison d'un évaporateur pour 14 m^3. Même lorsqu'on a utilisé un dosage massif (un évaporateur pour 1,7 m^3, soit 28 évaporateurs dans un logement de deux pièces), l'on n'a observé aucun effet toxique appréciable chez les occupants des maisons. Or, le dosage dépasse de loin celui qui est nécessaire aux campagnes d'éradication du paludisme. Ceci constitue un facteur supplémentaire de sécurité à l'actif de la méthode.