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Hazards of Insecticide Applications in Quebec[1]

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AN interesting outcome of the formation of the Research Institute of Industrial Hygiene and Air Pollution of the School of Hygiene, Université de Montréal, has been the comprehensive study made of the uses of insecticides throughout Quebec Province, particularly with respect to occupational health hazards.

In a preliminary study, more than 350 publications concerning pesticides were consulted. There was ample evidence to show that poisoning from insecticides could occur in three occupational areas, manufacture, formulation and application, via the three routes of exposure: oral, respiratory and dermal.

Formulating

It was considered, however, that the safety measures usually applied in modern industrial processing would no doubt be in effect in the majority of insecticide manufacturing and formulating plants. This was later borne out by the results of a field survey which was made during a casual visit to one such plant engaged in the formulation of aldrin, heptachlor and guthion (1). In the general areas of the plant, respirators were not usually worn. The mean air concentration and respiratory exposures were found, for example in the case of guthion, to be 0.09 mg./cu.m. and 1.58 mg./man/hr. In the blending areas of the plant the mean air concentration, respiratory and dermal exposures were found to be 6.9 mg./cu.m., 1.03 mg./man/hr. and 10.1 mg./man/hr. In the blending areas, workers were well protected by respirators and suitable clothing. As a result of these exposures, there was no serious depression of cholinesterase levels as shown in Table I.

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Outdoor Spraying

Rather more concern was felt for the hazard which might arise from the possibility of dermal exposure during the spraying of some of the more highly toxic compounds. Both outdoor spraying and spraying in confined spaces warranted consideration. A field survey of outdoor spraying operations began during the spraying season of 1962.

Measurements of the respiratory and dermal exposure of spray operators to a number of insecticides, and comparison of the results obtained with the toxic doses injurious to animals, were used to assist in the evaluation of the potential health hazard (2). Investigations were made in several areas of the province.

At the time of the survey, insecticides were being used in apple orchards and in the spraying of fields of grain, potatoes, vegetables and small fruit. The spraying machines in most cases were modern air-blast machines hauled by a tractor, although crop treatment was also being achieved by means of several high pressure jets. Occasional use was being made of hand-controlled, high-pressure spray nozzles fitted as an auxiliary to air-blast machines. The application of insecticides by aircraft was also in progress.

Farmers occupied with seasonal spraying were kept uninformed of the intended investigation in order that the data collected might accurately reflect present-day spraying practices in the province, and provide reliable information from which a sound assessment of the hazard could be made.

In orchard spraying, the average number of trees sprayed per tank of insecticide was 300, with tank capacities up to 500 gallons. Acreages of potatoes and vegetables sprayed per tank varied from one to 16. During aircraft spraying, up to 27

TABLE I—Cholinesterase in Blood Serum of Workers Before and After Formulating Guthion 25 W P

Subject	A Reference Activity*	B Reference Activity†	Ratio B/A in %
1	6.34	4.93	77.7
2	7.26	6.43	88.4
3	5.02	4.32	86.0
4	7.20	6.24	86.6
5	7.42	6.75	90.9
6	7.30	6.53	89.4
7	5.86	4.61	78.6
8	7.20	6.14	85.2

Data provided by the Industrial Hygiene Division of the Provincial Department of Health of the Province of Quebec.

*Reference activity refers to the cholinesterase activity determined on blood samples obtained before exposure, in ΔpH units.

†Actual activity refers to the cholinesterase activity determined on blood samples obtained after exposure, in ΔpH units.

The cholinesterase activity is given as micromoles of O-Nitrophenol liberated per ml serum per min. at 37° C.

TABLE II—Concentrations of Insecticides Used on Crops

Crops Sprayed	Insecticide	Lb/100 Gal.
Apples	Malathion 25 W P	2
Oats	Malathion 25 W P	1
Cabbage	Malathion 25 W P	2.5
Potatoes	Malathion 25 W P	2
Apples	Sevin 50 W P	0.5 to 8.0
Potatoes	Endrin 20 E	2.5
Cabbage	Endrin 20 E	1.25 to 2.5
Potatoes*	Endrin 20 E	60
Potatoes, onions, carrots*	Endrin 20 E	60
Strawberries	Endrin 20 E	1.5
Apples	Parathion 15 W P	0.4 to 4.0
Apples	Guthion 25 W P	0.5 to 6.0

*Aircraft spraying.

TABLE III—Air Concentrations of Insecticides During the Spraying of Orchards, Small Fruits, Vegetables and Grain

Insecticides	Samples	Air Concentration Mg/Cu Meter	
		Range	Mean
Malathion	4	0.41–0.76	0.59
Sevin	7	0.18–0.81	0.60
Endrin	3	0.00–0.00	0.00
Endrin*	3	0.02–0.26	0.05
Parathion	10	0.05–0.26	0.15
Guthion	20	0.05–2.55	0.67

*Aircraft spraying.

acres of potatoes were sprayed at a single coverage with up to 45 gallons of solution. The duration of the spraying cycle for a particular crop ranged from five to 80 minutes. There were from one to 15 sprayings per day and a similar number of spraying days per season.

Spray compositions in use were formulations of malathion, mixtures of malathion with DDT, sevin, mixtures of sevin with cyprex, captan and guthion; endrin, mixtures of endrin with dichlone and tedion; parathion, mixtures of parathion with captan, cyprex, crag and lead arsenates; guthion, mixtures of guthion with genite, cyprex, captan and crag. The formulations included emulsions and wettable powders. The concentrations of the active constituents of the spray compositions are given in Table II.

Air samples were collected at the tractor operators' breathing zone using all-glass fritted absorbers and electric or hand-operated suction pumps. In all, some 65 air samples were collected and analyzed during the survey with results as summarized in Table III. The table shows the concentrations of endrin determined in the air inside aircraft to which pilots were exposed during the spraying of potato and vegetable fields.

Air concentration values were used to calculate respiratory exposure. Calculations of respiratory exposure by means of air concentration values require an assumed tidal volume and respiratory rate; an assumed lung ventilation of 444 litres per hour (3) was used in calculating these exposures.

Respiratory exposures were also determined by the technique of attaching filter pads to double-unit respirators. The respirators were worn by observers sitting beside spray operators on the tractors. Determination of the quantities of insecticides deposited on the filter pads constitutes a direct measure of respiratory exposure. The results obtained are shown in Table IV. This table shows also the results which were obtained for dermal exposures measured by means of alpha-cellulose absorbent pads strapped to the forehead and wrists of observers, similarly stationed beside tractor operators. The insecticides collected on the absorbent pads were extracted, analyzed and converted to dermal exposure by calculation using Berkow's method, incorporating the means of the determined forehead and wrists deposits with an assumed total exposed surface area of unclothed body parts of 3.16 sq. ft. (4). During the spraying operations several spraymen wore respirators. The respiratory exposures quoted, however, are the exposures which would have occurred had respirators not been worn. The minimum clothing worn comprised shoes, socks, long trousers, an open-necked short-sleeved shirt, no hat nor gloves. Some spraymen wore more protection, some less. The dermal exposures shown in Table IV represent the exposures which would have occurred had the spraymen been wearing the minimum clothing. Actual count showed that of the total number of operators involved, 29% used cloth overalls, 39% used some form of head protection such as cap or helmet, 27% used gloves and 48% had no protection whatsoever. Only 11% of the operators used respirators.

The respiratory and dermal exposures

TABLE IV—Exposure of Spray Operators to Insecticides

		Exposure Mg/Man/Hr			
		Respiratory		Dermal	
Insecticides	Subjects	Range	Mean	Range	Mean
Malathion	4	0.03–0.13	0.08	1.5 – 4.9	2.5
Sevin	7	0.24–0.53	0.29	18.5 –30.3	25.3
Endrin	3	0.00–0.00	0.00	0.0 – 0.30	0.15
Endrin*	3	0.02–0.14	0.08	0.88– 1.64	1.18
Parathion	10	0.01–0.05	0.03	0.7 – 5.8	2.4
Guthion	20	0.07–1.60	0.26	1.1 –69.7	12.6

*Aircraft spraying.

of some 52 subjects were measured during the survey. The mean respiratory exposures to malathion, sevin, parathion, and guthion during air-blast spraying were 0.08, 0.29, 0.03 and 0.26 mg./hr. respectively.

An examination of Table IV discloses also that the pilots inside aircraft during the spraying of endrin received a mean respiratory exposure of 0.01 mg./hr. Operators at ground level during high-pressure spraying with endrin received no detectable respiratory exposure. This may be accounted for by the fact that the high-pressure spraying of potatoes, cabbage, onions, strawberries, etc. was being accomplished by spraying directly downwards into the crop and into the soil.

The mean dermal exposures of spray operators to malathion, sevin, parathion and guthion during air blast spraying were 2.5, 25.3, 2.4 and 12.6 mg./hr. The mean dermal exposure to endrin during aircraft spraying was 1.1 mg./hr., while under high-pressure spraying conditions it was 0.15 mg./hr. Here again the low value may be attributed to the direct injection of endrin into the ground.

Indoor Spraying and Vaporizers

In 1963, the survey was extended to indoor spraying operations. Systox was investigated during spraying operations in five commercial greenhouses situated in various districts of the province. Cattle spraying with methoxychlor inside barns was investigated on seven farms. The spraying of diazinon and chlordane by professional exterminators for the eradication of silverfish and roaches in grocery stores, apartment buildings, factory workshops and cafeterias was studied. Tests of continuous lindane vaporizers used in the elimination of houseflies in restaurants, hotel dining rooms, taverns, food stores, meat markets and hospitals were also carried out.

Spraying equipment ranged from small manually-operated domestic sprayers to hose-type sprayers having a reservoir capacity of 200 gallons. The duration of the spraying cycles in all these operations varied from two to 90 minutes, with but one or two sprayings daily.

Determinations of air concentrations, respiratory and dermal exposures were made by the techniques previously indicated. The quantities of lindane, systox and chlordane deposited on walls, floors and ceilings were also determined.

The respiratory and dermal exposures of some 29 subjects were measured during the latter survey. Of the respiratory and dermal exposures of 81 subjects measured during the two surveys, 1962 and 1963, the maximum exposures to each insecticide studied were converted to an exposure value in terms of the "per cent of toxic dose". The procedure for the calculation of the fraction of the toxic dose absorbed per hour has been described by Durham and Wolfe (5) and is based on dermal median lethal dose (LD_{50}) values for male white rats. The animal toxicities used in these calculations are listed in the Clinical Memoranda on Economic Poisons (6). The exposure values are given in Table V. The values quoted are maximum values and, as mentioned earlier, represent exposures occurring in the absence of respirator or protective clothing.

TABLE V—Exposure Values of Spray Operators to Insecticides, Calculated as "Per Cent Toxic Dose"

Insecticide	% Toxic Dose
Malathion	0.002
Diazinon	0.022
Methoxychlor	0.003
Chlordane	0.009
Sevin	0.025
Endrin	0.29
Parathion	0.43
Guthion	0.72
Systox	1.43

Discussion

It has been stated (7) that the health hazard from pesticides is related to the toxicity and nature of the material used, the duration of exposure, the training of the applicator, the care taken in application and the suitability of the spraying equipment. From the exposure values determined in the above surveys, it is evident that spray operators were not subjected to doses of insecticides approaching acute toxic levels. While the operators were frequently exposed to air concentrations exceeding established Threshold Limit Values (8), the maximum recorded exposure value was but 1.4% of the toxic dose, which occurred during the application of systox. The low exposure values were due to the comparatively short duration of the spraying cycles. However, with the possible exception of the spraying of systox in greenhouses where protective clothing was worn by the operators, and the spraying of diazinon and chlordane by well trained professional exterminators, the attitude of many of the spraymen was one of carelessness, and there was evidence of unfamiliarity with the very dangerous nature of some of the materials which they were using.

During the continuous vaporization of lindane, the rate of vaporization was found to be one-half gram tablet of lindane per 24 hours, in an average volume of 8,799 cu. ft. This is a slightly lower rate of vaporization than the maximum rate of one gram per 1,500 cu. ft. in 24 hours, as recommended by the U.S. Interdepartmental Committee on Pest Control (9). One notable exception was the use in a hospital kitchen of approximately 16 one-half gram tablets per day, in three vaporization units in an air space of no more than 4,900 cu. ft. This led to an atmospheric concentration of lindane of 0.78 mg./cu. m. of air, which is in excess of the Threshold Limit Value for lindane.

There is a continual need for education and medical surveillance wherever insecticides are used and particularly where new compounds are introduced. Consequent upon the above investigations, medical surveillance was introduced in Quebec during the 1964 spraying season. A number of medical students attached to the Research Institute of Industrial Hygiene and Air Pollution of the Université de Montréal participated in the control of the health of spray operators by means of field surveys and the collection of statistical data. Although of a preparatory nature, this program could be expanded by the public health authorities, if they deem it advisable.

The possibility of chronic poisoning associated with the repeated absorption of minute quantities of insecticides such as may remain in foods as residues, is receiving considerable attention from numerous authorities. "Tolerance" levels for approximately 70 pesticides have been established for a wide variety of foods in Canada by procedures recommended by the World Health Organization and the Food and Agricultural Organization of the United Nations, as indicated by Chapman (10).

The possibility of chronic poisoning in workers engaged in apple growing has been investigated by the Research Institute of Industrial Hygiene and Air Pollution, School of Hygiene, Université de Montréal, in a three-year study (11). It is believed that no similar study had been undertaken anywhere prior to 1960.

While the results of these studies, carried out in the Province of Quebec, may offer some reassurance with respect to the occupational health hazard from acute poisoning, they nevertheless indicate a need for continued vigilance during the application of insecticides, particularly with reference to the chronic effects which may be produced.

Résumé

Une étude a été effectuée sur les dangers pour la santé qui peuvent survenir, du point de vue professionnel, à la suite de la manipulation des insecticides.

Les recherches furent effectuées dans les champs de culture et dans les usines, sur des fermes et à l'intérieur des étables, dans des serres et des épiceries, dans des hopitaux et dans des hôtels, y compris des restaurants et des tavernes.

Les expositions par les voies respiratoires et par contact avec la peau chez les travailleurs préposés à l'épandage des insecticides ont été mesurées avec précision et ces expositions furent comparées avec les doses toxiques pour les animaux.

Les employés furent fréquemment exposés à des concentrations dans l'air d'insecticides qui excédaient les seuils de tolérance (Threshold Limit Values) établis.

En bien des cas les employés négligeaient de prendre les précautions nécessaires et on remarquait chez eux un manque évident d'information concernant les risques que pouvaient comporter pour la santé certains des produits chimiques utilisés. Cependant, étant donné les courtes périodes d'exposition, les employés ne furent pas exposés à des doses susceptibles de provoquer une intoxication aiguë.

Une étude parallèle sur les effets chroniques associés à la manipulation des insecticides dans la Province est aussi mentionnée.

Il ressort des résultats obtenus dans la présente étude qu'il est nécessaire de continuer à se tenir en alerte partout où l'on manipule des insecticides. Un programme de surveillance médicale a été initié dans certaines régions de la Province de Quebec au cours de l'année 1964. Il faut espérer que ce programme se développe dans les années qui vont suivre.

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