INCAP Publication I-1045

Arch. Environm. Contam. Toxicol. 8, 43-58 (1979)

Archives of Environmental Contamination and Toxicology

Contamination of Human Milk with Chlorinated Pesticides in Guatemala and in El Salvador

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Abstract. In Central America huge amounts of persistent organochlorine pesticides are being used. This paper presents data on organochlorine residues in human milk. The samples studied were collected from areas with different spraying patterns. The results show very high contamination rates with organochlorine pesticides, especially with DDT.

The highest levels were found in cotton-growing areas. Compared with residue levels in areas where cotton is not grown the difference was found to be statistically significant. Many of the quoted values are among the highest reported for the Western World. However, very high residue levels were also found even in Guatemala City, suggesting that other than agricultural uses of pesticides are important contamination sources.

It is believed that these high levels of pesticide residues in human milk reflect a high contamination among the population in general.

Contamination of the environment with persistent chlorinated pesticides has become a world-wide problem of increasing concern. Even if the trend in agricultural practice is a shift to non-persistent pesticides, huge amounts of persistent and liposoluble organochlorines are still being used in Central America.

A considerable amount of evidence has been published in relation to the toxicity of these compounds. However, the practical implications of chronic low-level human exposure to these compounds, have not yet been clarified.

Hayes Jr. *et al.* (1971) have shown that an individual may ingest up to 35 mg of DDT daily for 21 months without showing definite clinical or laboratory evidence of injury. As to the detoxication process, they found that the urinary excretion of DDA was proportional to the ingested dose (Hayes Jr. *et al.* 1971).

Exposure to DDT stimulates the activity of the liver microsomal enzymes, which results in an enhanced capacity of the organism to carry out the detoxication process. For this same reason the response of the organism to drugs may also be modified (Radomski *et al.* 1968).

Formulation workers who have been highly chronically exposed to DDT

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0090-4341/79/0008-0043 $03.20

have not shown any evidence of adverse effects (Poland *et al.*, 1970). In the WHO Malaria Control Campaign no symptoms of DDT poisoning have been observed among sprayers or among the inhabitants of the sprayed areas (WHO, 1969). This seems to confirm that DDT, as well as a number of other chlorinated pesticides, has relatively low acute toxicity.

On the other hand, the effects of chronic toxicity, that is, over longer periods of time, must be considered. As can be seen from the following paragraphs, these effects may be subtle and only evident at laboratory level, a fact that does not make them less dangerous.

Several investigators have found that when certain pesticides are absorbed, they are bound to serum proteins with the consequent inhibition of the normal function of these proteins (Schoor 1973).

Desaiah and Koch (1975) have shown that Kepone and DDT inhibit the ATP-ases activity in fish. The synthesis of ATP is also reduced; consequently, less ATP is available as a source of energy.

Some of the chlorinated pesticides have hormonal and antihormonal activity. Recent evidence shows that DDT and dieldrin accumulate in the prostate of rats and mice inhibiting the absorption of testosterone and thus affecting the male reproductive system (Blend 1975; Smith *et al.* 1972).

Several investigators have stated that large quantities of DDT induce tumors in the liver of rats, mice and fish. In one study quantities similar to those absorbed by formulators were used (Turosov *et al.*, 1973; Fitzhugh and Nelson 1947; Halver 1967; Tomatis *et al.* 1974). The incidence of hepatomas seems to be slightly higher in males than in females (Turusov *et al.*, 1973).

Russian investigators have found women living in areas where DDT is used to have more stillbirths and abortions than women from areas where DDT is not used at all (Medvied 1970).

Nutritional factors have some influence on the severity of the toxicity: protein deficiency increases the toxicity for a large number of pesticides by reducing the activity of microsomal enzymes, and this effect decreases their metabolizing and detoxication capacity (Shakman 1974).

DDT and dieldrin have been shown to reduce the liver stores of vitamin A and this is specially evident when methionine is the limiting amino acid in the diet (Shakman 1974).

Dietary fat plays an important, direct role in the toxicity of chlorinated liposoluble hydrocarbon pesticides. Food deprivation leads to an increased fat turn-over, and this may cause a drastic increase in the blood concentration of these pesticides (Shakman 1974).

It has been proposed that the pesticide-induced mircrosomal enzymatic activity accelerates vitamin D metabolism, resulting in disorders of calcium metabolism (Shakman 1974).

The accumulation of DDT and its metabolites in fat is higher in individuals living in hot climates (USDHEW 1965). The reason is that in tropical regions where constant domestic pest control has to be carried out, non-dietary sources such as house dust may be as important as the diet in producing human exposure (Davies *et al.* 1971; Davies *et al.* 1975). Under normal conditions it is considered that 90% of human exposure comes from food (Campbell *et al.* 1965).

These factors may prove to be of great importance in the Central American region because of its tropical climate and high prevalence of malnutrition. As referred to in previous paragraphs nutritional deficiencies may accentuate the toxicity of the pesticides.

Several studies have shown racial differences in blood levels of DDT with a two-to-three-fold accumulation among blacks. This is believed to be associated with the deficiency of glucose-6-phosphate dehydrogenase observed in the erythrocytes of blacks (Keil *et al.* 1974). This enzyme participates in the detoxication mechanism.

It is evident that most of the experiments with pesticides have been carried out in animals. Therefore, one must be cautious in extrapolating results to humans. The velocity of elimination of pesticides, for example, is slower in humans than in monkeys, dogs and cats (Morgan and Roan 1971).

In spite of the considerable amount of research on this subject, it is not possible as yet to predict to what extent a chronic burden of chlorinated pesticides will affect the human being, within a relatively short time or in future generations.

When pesticides have to be used, the only logical approach is to select them with the utmost care and use them in a rational manner to reduce to a minimum the contamination of the environment. Human and environmental hazards must be weighed against the benefits expected to be derived from them.

In industrialized countries, strict regulations for the use of toxic substances have been introduced, and certain pesticides have been completely prohibited. These measures have resulted in a progressive decrease in contamination (Arena 1970; Westöö 1974).

The situation in developing countries is very often a different one. Until recently, Central America lacked appropriate legislation on the use of pesticides, and nowadays although many regulations exist in this respect, an adequate system to implement them is frequently nonexistent. The sub-tropical and tropical climates in the area often permit more than one harvest a year, a fact that favors great insect proliferation. To protect these harvests, therefore, it is necessary to spray heavily with pesticides. However, with time, greater amounts are required since insect resistance is increasing; mixtures of chlorinated pesticides and organophosphates are used: in cotton-farming areas 30 to 40 such applications a year are the usual practice. Frequently the needed knowledge about pesticides and their proper use is also lacking, and this leads to an abuse instead of an appropriate use of these compounds.

At the same time, in most developing countries little work has been done to establish the extent and magnitude of pesticide pollution.

Preliminary studies carried out in Guatemala revealed a high degree of contamination in food, especially in meat, fish and human milk (Olszyna-Marzys 1970; Zeissig 1973).

Further studies on chlorinated pesticides in human milk were undertaken between 1971 and 1975. Even if the principal interest has been to determine the degree of exposure of the suckling child, we consider that—indirectly—the results also provide an idea of the contamination of the general population. In lactating cows, Fries and Marrow Jr (1972) have found that there is a correlation between milk fat and body fat concentration of organochlorine compounds.

Concentrations of chlorinated pesticides in the human milk samples analyzed in Guatemala were extremely high. In fact, as far as we know, the amounts of DDT are the highest reported in the Western world.

Materials and Methods

The spraying density in a specific area is related to the kind of crop which is grown there. For this reason, in the studies herein described the human milk samples used were collected from areas with different spraying patterns. The mothers came from low-income families, whose staple diets consisted of beans, rice and corn. The communities under study were small and samples of milk from all the lactating mothers that were willing to cooperate, were included. These communities are shown in the following map of Central America and Panama (Figure 1).

Samples were collected in either glass or aluminum widemouth bottles of about 25 ml capacity. The caps were covered with aluminum foil. The bottles and the caps were previously washed with detergent and boiling water, rinsed with tap water and distilled water, and finally rinsed with Nanograde® acetone and petroleum ether. Blank analyses of random bottles were carried out, and the absence of interfering compounds was demonstrated. Quantities between five and twenty ml samples were collected by manual expression and were frozen until they were analyzed.

In all our studies, we used the "micromethod for the determination of chlorinated pesticides in human or animal tissue and human milk", published by the U.S. Environmental Protection Agency (EPA) 1971–74. The method consists in extracting 2 ml of milk with acetonitrile, partition into hexane, Florisil® clean-up and analysis by gas-liquid chromatography (GLC). A mixture of 13 chlorinated pesticide standards were carried throughout the whole procedure with each set of six samples. The standard mixture was prepared in the laboratory and consisted of α-, β- and γ-HCH, heptachlor epoxide, aldrin, dieldrin, endrin and the o,p' and p,p' isomers of DDT, DDE and DDD. Five of the 121 samples analyzed were so far out of range that they were not considered in the calculation of the

Fig. 1. Communities in Guatemala and El Salvador selected for sampling of mother's milk

means. For this estimate the Dixon test for "outliers" was used (Dixon 1953). About half of the total number of samples were analyzed for fat content applying the procedure for determination of blood lipids described by Bragdon (1951), adapted for human milk. Polychlorobiphenyl (PCB) determinations were made in some samples according to the Armour and Burke's method (1970), in order to detect possible interferences with the analysis. The average relative standard deviation between duplicates was 9%, with the recovery rate ranging from 80 to 105 per cent.

A Tracor MT 220 gas chromatograph was used, with a Ni^{63} detector, off-column injection; the carrier gas was N_2 at 60 ml/min. The operating temperatures were: Injection port 225°C; transfer line 275°C; column 200°C; detector 275°C. The glass columns were 6 ft × ¼ in O.D. (1.8 m × 6 mm). Two different column packings were used for the identification and confirmation of the pesticides in the samples: 1) 1.5% OV-17/1.95% QF-1 on Supelcoport® 80/100 mesh and 2) 4% SE-30/6% QF-1 on Supelcoport 100/120 mesh.

Study No. 1—Guatemala

The first study was carried out in 1971 with samples from three rural communities of Guatemala: a) "El Rosario" in Champerico, department of Retalhuleu on the southern coast; main crops: corn and sesame; completely surrounded by cotton plantations; b) "Cerro Colorado" in La Gomera, department of Escuintla on the southern coast; main crop: corn; a cotton plantation functions on one of the extremes of the community, and c) "La Bomba" in Chiquimulilla, department of Santa Rosa in the south-eastern part of the country; main crop: corn. No cotton is grown in the area.

The results, previously published in spanish (Olszyna-Marzys *et al.* 1973), are summarized in Table 1.

The highest contamination is due, by far, to DDT and its metabolites, which were found in all of the samples examined; pp-DDE was the major metabolite. The reported total DDT residues include the o,p' and the p,p' metabolites of DDT, DDE and DDD. Residues of hexachlorocyclohexane (HCH), also known as benzene hexachloride (BHC), were found in 83% of the samples. The reported total amounts have contributions from the α-, β- and γ-isomers with one, two or all three present. Dieldrin and heptachlor epoxide were detected in 50 and 48% of the samples, respectively.

In the two communities from the cotton-growing areas, the average amounts of DDT were 1.84 and 3.06 ppm. This is 37 and 61 times higher than the USA tolerance and the "practical residue limit" of 0.05 ppm in the whole cow's milk established by FAO/OMS (1970). No tolerance limit exists for human milk; hence, the "practical residue limit" for cow's milk is used for comparative purposes. In the community without cotton the average DDT residue was 22 times higher than that limit.

FAO/OMS "practical residue limits" for dieldrin, heptachlor epoxide and γ-HCH (lindane) in whole cow's milk are 0.005, 0.005 and 0.004 ppm, respectively (FAO/OMS 1970). No limit exists for other isomers of HCH. After DDT, HCH isomers (Table 1) represent the highest contamination source in the milk. The average values for dieldrin and heptachlor epoxide are below the above-mentioned limits.

Studies carried out at the Institute of Nutrition of Central America and Panama (INCAP), showed that a child weighing 10 kg consumes 850 ml of milk

Table 1. Chlorinated pesticides in human milk Guatemala (Values expressed in ppm, whole-milk basis)

			Total DDT		Total HCH		Dieldrin		Heptachlor epoxide	
Community	Crop	No. of samples	*Mean ± S.D.* (Range)	Positive samples	Mean ± S.D. (Range)	Positive samples	Mean ± S.D. (Range)	Positive samples	Mean ± S.D. (Range)	Positive samples
El Rosario, Champerico	Cotton corn, sesame	27	1.84 ± 1.25 (0.342–4.97)	27	0.006 ± 0.005[c] (0–0.019	23	0.002 ± 0.003 (0–0.010)	23	0.007 ± 0.002 (0–0.008)	19
Cerro Colorado, La Gomera	Corn cotton	9	3.06 ± 1.81[a] (1.57–6.68)	9	0.015 ± 0.019 (0–0.057)	5	n.d.**		n.d.	
La Bomba, Chiquimulilla	Corn	10	1.11 ± 0.80[b] (0.411–1.77)	10	0.24 ± 0.009[d] (0.010–0.035)	10	n.d.		0.003 ± 0.007 (0–0.21)	3

* S.D. = Standard Deviation.
** n.d. = Not detected.
[a] Excluding one sample containing 12.21 ppm.
[b] Excluding one sample containing 11.50 ppm.
[c] Excluding one sample containing 0.069 ppm.
[d] Excluding one sample containing 0.101 ppm.
Values below 0.001 ppm are not reported.

per day (Olszyna-Marzys *et al.* 1973). The "Acceptable Daily Intake" (ADI) for DDT, recommended by FAO/OMS is 0.005 mg/kg body weight. The maximum intake for a child weighing 10 kg would then be 0.05 mg of DDT per day. Therefore, the average levels of DDT in the milk from the three communities under study would exceed that amount (0.05 mg DDT/day) 31, 52, and 19 times, respectively.

This shows that either of the two criteria, "Practical Residue Limit" or "Acceptable Daily Intake", lead to the same conclusion: the average amounts of DDT in human milk are about 35, 55 and 20 times higher than the tolerance allows. Tolerances of this kind are based on toxicological studies and offer a security factor of about one hundred. Six of the analyzed samples exceeded more than 100 times the tolerance limits for DDT (5 ppm).

Of five samples of cow's milk collected for comparative purposes in "La Bomba", the non-cotton growing community, one exceeded slightly the limit, with 0.077 ppm of DDT. Only very low levels of HCH, heptachlor epoxide and dieldrin were detected. This confirms the fact, found in other parts of the world, that human milk is more contaminated than cow's milk. Breast-feeding mothers have been shown to excrete considerably greater quantities of p,p'-DDE with the milk than ingested with the food (Adamović and Sokić 1973). Another factor is the "biological magnification" with humans at the end of the food chain.

There are several potential sources for the observed milk contamination: contaminated food and water, domestic use of pesticides, spraying programs, spraying on small farmers' privately cultivated plots, and by airplane, on big farms and plantations. It would be impossible to quantitate the relative contribution of each of these sources. However, statistical analyses of the results show a heavy contribution from big-scale agricultural use. There is a statistically significant difference between the residues of DDT found in the community where cotton is not raised and each of the other two located in cotton-growing areas ($P < 0.05$). No significant difference was observed between the two communities in the cotton-growing areas.

Study No. 2—Guatemala (Thesis Research Work)

The second study was carried out in 1974, also in Guatemala, with the samples collected from the following areas shown in Figure 1: a) the Guatemala City area with limited use of pesticides; b) "Morales", department of Izabal, in the northeastern region, cultivated mainly with banana plantations, using moderate spraying, and c) Escuintla, on the southern coast, which is a heavily sprayed cotton-growing area.

The results, partially published (Thesis work, Pardo 1974), are shown in Table 2 on a whole-milk basis. Total DDT and total HCH are reported as explained for Table 1. Again, the main contaminants were DDT and its metabolites, which were found in all the samples with p,p'-DDE as the major metabolite. With only one exception, all the values exceeded the 0.05 ppm limit, the means being 10, 51 and 71 times higher, respectively. One sample from "La Gomera", Escuintla, contained 9.26 ppm of DDT, which is 185 times higher than the limit. The woman from whom this sample was taken had been living in the community for 25 years and worked as a cotton picker. The results confirm the previous

Table 2. Chlorinated pesticides in human milk, Guatemala (Values expressed in ppm, whole-milk basis)

Community	Crop	No. of samples	Total DDT Mean ± S.D.* (Range)	Total DDT Positive samples	Dieldrin Mean ± S.D. (Range)	Dieldrin Positive samples	Heptachlor epoxide Mean ± S.D. (Range)	Heptachlor epoxide Positive samples
Guatemala, City	—	15	0.480 ± 0.345 (0.025–1.03)	15	n.d.**		n.d.	
Morales, Izabal	Banana	10	2.55 ± 1.68 (1.14–6.60)	10	0.005	1	0.002	1
Escuintla	Cotton	10	3.54 ± 2.55 (0.600–9.26)	10	0.070	1	n.d.	

* S.D. = Standard Deviation.
**n.d. = Not detected.
Values below 0.001 ppm are not reported.

conclusion that there is a definite correlation between the concentration of DDT in the milk and the spraying practice in the area. The difference between the average amounts in the Guatemala City area and each of the two rural communities studied is statistically significant ($P < 0.001$), with no significant difference between the two rural communities. The results also indicate that crop spraying on a large scale, using aircraft, contributes heavily to contamination. But, since even the samples from the Guatemala City area contained high levels of DDT, additional sources of contamination are evident.

Study No. 3—El Salvador

In order to establish if similar results would be found in other Central American countries, 40 human milk samples from El Salvador (Guatemala's neighboring country) were analyzed in 1973–1974. The samples were collected in the Health Center of "Santiago de María", province of Usulután. This small town is surrounded by coffee plantations which use limited to moderate spraying. However, the distance to the nearest cotton-growing area on the coast is short, and people commute frequently within this area, especially in the cotton-picking season. The results are shown in Tables 3 and 4. The concentrations of total DDT in the Salvadorean samples were slightly higher than those found in Guatemala City. The average amounts was 14 times higher than the 0.05 ppm limit. The distribution of the DDT values is shown in Figure 2: 35% of the samples contained less than 0.50 ppm, and 80% had levels below 1.0 ppm.

Besides DDT, in 68 and 55% of the samples, respectively, HCH and dieldrin were also found. Heptachlor epoxide was detected only in 2 of the 40 samples analyzed (5%). The levels of these pesticides are very similar to those found in Guatemala. The mean values from the different areas are listed in an ascending order, according to their DDT content, in Table 5.

Table 3.(part 1) Chlorinated pesticides in human milk, El Salvador (Values expressed in ppm, whole-milk basis)

Sample	p,p'-DDT	p,p'-DDE	p,p'-DDD	o,p'-DDT*	DDT total	α-HCH	β-HCH	γ-HCH	HCH total	Dieldrin	Heptachlor epoxide
1	0.285	0.526	—	0.013	0.824	—	0.040	—	0.040	0.003	-
2	0.069	0.176	—	0.007	0.252	—	0.022	—	0.022	—	—
3	0.046	0.158	—	0.004	0.208	—	0.011	—	0.011	0.003	—
4	0.104	0.412	—	—	0.516	—	0.014	—	0.014	—	—
5	0.205	0.291	0.010	0.008	0.514	0.003	0.010	0.004	0.017	0.004	—
6	0.121	0.338	0.007	0.003	0.469	0.002	0.019	0.002	0.023	0.003	—
7	0.495	0.798	0.005	0.014	1.312	—	0.029	—	0.029	0.002	—
8	0.103	0.291	0.002	0.017	0.413	—	—	—	—	0.015	—
9	0.180	0.265	0.003	0.002	0.450	—	0.004	—	0.004	—	—
10	0.091	0.223	0.005	—	0.319	0.003	0.015	—	0.018	0.003	—
11	0.175	0.373	0.007	0.034	0.589	—	0.089	—	0.089	0.006	—
12	0.058	0.205	0.002	0.012	0.277	—	0.014	—	0.014	0.004	—
13	0.284	0.568	0.047	0.063	0.962	0.005	—	—	0.005	0.014	—
14	0.265	1.620	0.005	0.069	1.959	0.002	0.015	—	0.017	0.004	0.004
15	0.178	0.524	0.006	0.007	0.715	—	0.020	—	0.020	0.003	—
16	0.121	0.454	0.006	0.006	0.587	—	—	—	—	—	—
17	0.182	0.711	0.009	0.008	0.910	—	0.007	—	0.010	0.002	—
18	0.089	0.143	0.005	0.006	0.243	—	0.004	—	0.004	0.002	—
19	0.203	0.830	0.023	0.014	1.070	—	—	0.001	0.001	0.009	—
20	0.105	0.506	0.012	0.006	0.629	—	0.013	0.002	0.015	0.004	—

Including very small amounts of o,p'-DDE.
Values below 0.01 ppm are not reported.

Table 3.(part 2) Chlorinated pesticides in human milk, El Salvador (Values expressed in ppm, whole-milk basis)

Sample	p,p'-DDT	p,p'-DDE	p,p'-DDD	o,p'-DDT*	DDT total	α-HCH	β-HCH	γ-HCH	HCH total	Dieldrin	Heptachlor epoxide
21	0.477	0.701	0.030	0.024	1.232	0.001	0.004	—	0.005	0.001	—
22	0.112	0.437	0.013	0.026	0.588	—	—	—	—	—	—
23	0.060	0.133	0.002	0.002	0.197	—	—	0.001	0.001	0.005	—
24	0.268	1.274	0.007	0.019	1.568	—	—	—	—	0.008	—
25	0.059	0.429	0.006	0.010	0.504	—	—	—	—	0.001	—
26	0.069	0.425	0.006	0.009	0.509	—	—	—	—	0.007	—
27	0.015	0.045	0.002	—	0.062	—	—	—	—	—	—
28	0.021	0.090	0.008	—	0.119	—	—	—	—	—	—
29	0.009	1.163	0.015	0.006	1.193	—	0.007	0.004	0.011	—	—
30	0.127	0.441	0.012	0.006	0.586	—	0.005	—	0.005	—	—
31	0.184	0.525	0.009	0.009	0.727	—	0.021	—	0.021	—	—
32	0.079	0.720	0.073	0.001	0.873	—	0.003	—	0.003	—	—
33	0.547	1.247	0.019	0.027	1.840	—	0.002	—	0.002	—	—
34	0.206	0.387	0.006	0.013	0.612	—	0.002	—	0.002	—	—
35	0.043	0.162	0.002	0.004	0.211	—	—	—	—	—	—
36	0.259	0.409	0.012	0.020	0.700	—	—	—		—	—
37	2.393	3.017	0.044	0.043	5.497	—	—	—	—	0.003	0.001
38	0.048	0.179	0.004	0.011	0.242	—	—	—	—	—	—
39	0.186	0.642	0.007	0.014	0.849	—	—	—	—	—	—
40	0.430	0.773	0.027	0.072	1.302	0.004	—	0.004	0.008	0.006	—

Including very small amounts of o,p'-DDE

Values below 0.001 ppm are not reported.

Table 4. Chlorinated pesticides in human milk, El Salvador (Values expressed in ppm, whole milk-basis)

			Total DDT		Total HCH		Dieldrin		Heptachlor epoxide	
Community	Crop	No. of samples	Mean ± S.D.* (Range)	Positive samples	Mean ± S.D. (Range)	Positive samples	Mean ± S.D. (Range)	Positive samples	Mean ± S.D. (Range)	Positive samples
Santiago de Maria, El Salvador	Coffee	40	0.695 ± 0.460[a] (0.062–1.96)	40	0.012 ± 0.010[b] (0.001–0.040)	27	0.005 ± 0.004 (0.001–0.015)	23	0.003 ± 0.002 (0.001–0.004)	2

* S.D. = Standard Deviation.

[a] Excluding one sample containing 5.50 ppm.

[b] Excluding one sample containing 0.089 ppm.

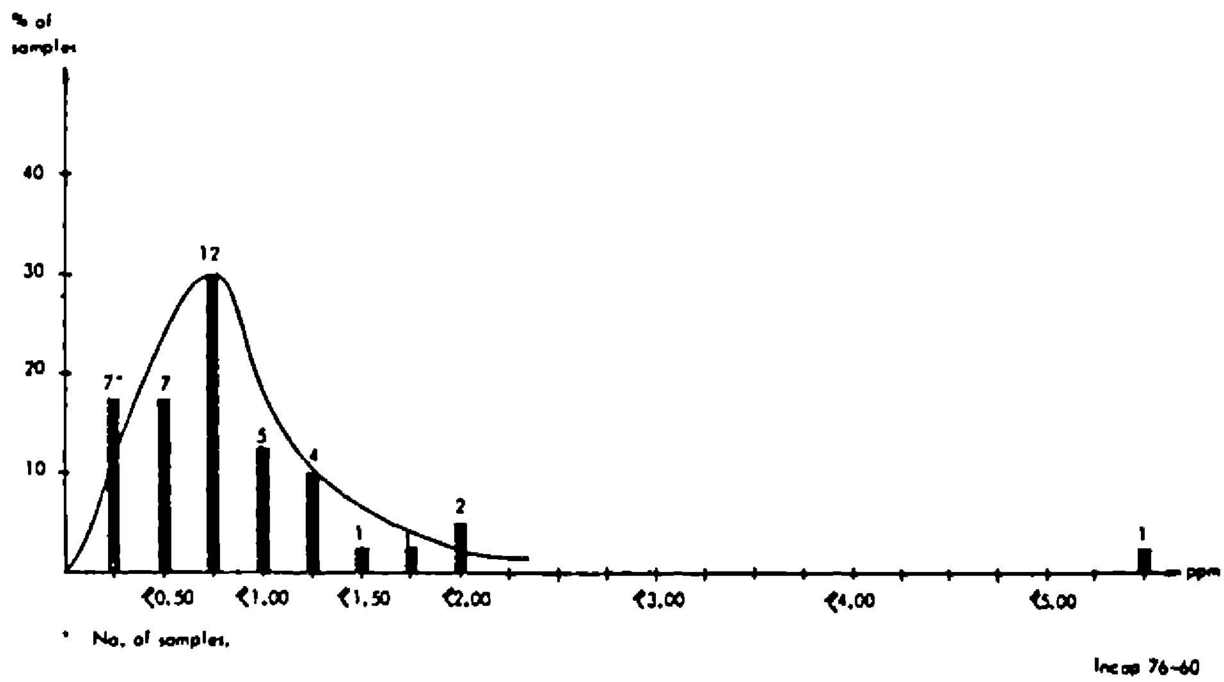

Fig. 2. Total DDT in human milk, El Salvador, C. A. (Expressed in ppm, whole-milk basis)

Discussion

Excluding heptachlor epoxide, many of the cited values for pesticide contamination in human milk are the highest reported in the Western world. For comparison purposes, some results from other countries are shown in Table 6, in

Table 5. DDT contamination in human milk, Guatemala and El Salvador (Values expressed in ppm)

Community	Main crops	No. of samples	Total DDT: Mean ± S.D.*	Min.	Max.
Guatemala, City	—	15	0.480 ± 0.345	0.025	1.03
Santiago de Maria, El Salvador	Coffee	40	0.695 ± 0.460	0.062	1.96[a]
La Bomba, Chiquimulilla, Guatemala	Corn	10	1.11 ± 0.80	0.411	1.77[b]
El Rosario, Champerico, Guatemala	Cotton, Corn, Sesame	27	1.84 ± 1.25	0.342	4.97
Morales, Izabal, Guatemala	Banana	10	2.55 ± 1.68	1.14	6.60
Cerro Colorado, La Gomera, Guatemala	Corn, Cotton	9	3.06 ± 1.81	1.57	6.68[c]
Escuintla, Guatemala	Cotton	10	3.54 ± 2.55	0.600	9.26

* S.D. = Standard Deviation.

[a] Excluding one sample containing 5.50 ppm.

[b] Excluding one sample containing 11.50 ppm.

[c] Excluding one sample containing 12.21 ppm.

Table 6. Chlorinated pesticides in human milk, different countries (Values exprressed in ppm, whole-milk basis)

Year published	Origin of samples	No. of samples	Total DDT			Total HCH			Dieldrin			Heptachlor epoxide		
			Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
1966	Italy	2	0.055											
1971	Texas, USA	9		0.018	0.089	0				0	0.003			
1969	Georgia, USA	5		0.050	0.099		0.0006	0.0157		0.003	0.0137		0.001	0.0024
1970	Germany	43	0.112			0.018								
1969	Belgium	20	0.130						0.0035					
1971	Canada	132	0.14						Tr.*			Tr.		
1964	Hungary	10		0.13	0.16									
1965	Great Britain	19		0.075	0.170		0.007	0.033		0.002	0.013			
1971	Texas, USA	7		0.025	0.195	0.004				0.002	0.021			
1971	Holland	50		0.01	0.17		0.001	0.016		0.0001	0.0107		0.0003	0.0035
1970	Sweden	22		0.058	0.229		0	0.001		0	0.005			
1971	Texas, USA	12		0.025	0.278		0.004	0.037		0	0.006			
1964	Calif., USA	7		0	0.37									
1968	Poland	51		0.27	0.49									
1969	Rumania	100	0.530											
1951	Washington, D.C., USA	32		0	0.77									
1974	Portugal	222		0.010	1.38					0.006	0.031			
1965	Russia	16		1.22	4.88									
1971	Canada	31								0.009	0.013			0.052

* Tr = Traces.

ascending order of DDT content (Olszyna-Marzys *et al.* 1973; Graca, Silva Fernandes and Maurað 1974). In the Central American study only the lowest amounts of DDT, those from the Guatemala city area and from "Santiago de María", El Salvador, are similar to the highest levels observed in Europe and the USA. Very high amounts of DDT have been reported in Russia (4.88 ppm) (Olszyna-Marzys et al. 1973), but these values were obtained by colorimetric procedures which are now known to give somewhat higher results than those detected by gas chromatographic methods. All the results shown have been calculated on a whole-milk basis to compare directly with the FAO/OMS "Practical Residue Limit" which is 0.05 ppm of total DDT in whole cow's milk. PCBs were not detected in any of the samples analyzed.

As the chlorinated pesticides accumulate in the adipose tissue, it is conceivable that, within the same area, milk with more fat would give higher values when calculated on a whole-milk basis.

Fat determination was made in 18 of the samples collected in El Salvador. The average percent content of fat ± standard deviation was 3.0 ± 0.8. No correlation was found between the amount of pesticides and the fat content in the milk.

The possible long-term effects in children highly exposed to DDT during their first months of life have never been established. It would be almost impossible to assess the direct effects of pesticides, since in these areas children are burdened with many other health problems such as maternal malnutrition, high incidence of infections, protein-calorie restrictions and intestinal parasites. These factors would tend to obscure the observations.

Conclusion

In Guatemala and El Salvador contamination of human milk with chlorinated pesticides is a serious problem. It is quite possible that this constitutes a reflection of a more general contamination of the population, even if no results on chlorinated pesticide residues in blood or adipose tissue have been reported from the area.

The results show that heavy use of pesticides in agriculture is an important contamination factor, but that other sources as well play an important role.

As a potential health hazard, the problem certainly merits closer attention on the part of national authorities. Obviously, more research is needed, and as a priority measure adequate control and penalty systems are urgent if the present situation is to be improved. Much abuse and many accidents are due to ignorance; therefore, education programs on the subject should be intensified. On a small scale, integrated pest control has also been successfully tried in the area (Romero 1976). This could be the solution to reduce drastically the need for pesticides and thus decrease contamination of the environment.

Acknowledgments. The authors are grateful to Licda. Cecilia Soto de Guido for her valuable assistance in obtaining the samples from El Salvador, and to Licda. Judith Pardo for her assistance during the 1973–1974 study in Guatemala. They also thank Mrs. María Octavia de Sosa for her help in the analysis of the samples.

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Manuscript received January 24, 1977; accepted February 28, 1978.