Table 3
Pesticide levels in female subjects from urban, semi-urban and rural areas

Pesticides (in ppm)	Urban		Semi-urban		Rural	
	Normal T_4 ($n=67$)	Depleted T_4 ($n=17$)	Normal T_4 ($n=19$)	Depleted T_4 ($n=3$)	Normal T_4 ($n=14$)	Depleted T_4 ($n=3$)
α-HCH	1.15±0.20	1.04±0.22	1.79±0.44	1.95±1.17	1.51±0.54	2.25±0.95
β-HCH	1.67±0.18	1.69±0.32	1.75±0.34	1.34±0.74	1.68±0.37	1.04±0.71
γ-HCH	0.85±0.23	0.87±0.35	0.84±0.34	1.41±1.21	0.82±0.4	0.83±0.68
Total-HCH	3.68±0.43	3.61±0.79	4.38±0.83	4.7±3.0	4.01±1.04	4.13±0.75
Dieldrin	2.41±0.37	5.5±1.37*	3.64±0.96	7.92±5.7	1.35±0.42	2.2±1.0
Heptachlor	1.34±0.18	1.16±0.29	1.71±0.39	1.12±0.56	1.31±0.45	1.42±0.86
p-p'-DDD	1.06±0.25	1.71±0.49	2.24±0.64	1.22±0.59	1.54±0.62	4.19±2.17
p-p'-DDE	2.11±0.33	2.24±0.48	1.72±0.49	2.78±1.74	3.18±1.14	4.19±2.09
p-p'-DDT	3.49±0.42	3.69±0.74	2.71±0.87	4.27±2.16	3.61±0.84	4.61±2.72
Total DDT	6.67±0.61	7.65±1.25	6.68±1.4	8.28±4.3	8.34±1.61	13.0±3.1
Total pesticides	14.12±1.16	17.93±2.39	16.42±2.47	22.03±10.7	15.03±2.87	20.76±4.6

* $P<0.05$.
Values represent mean±S.E.

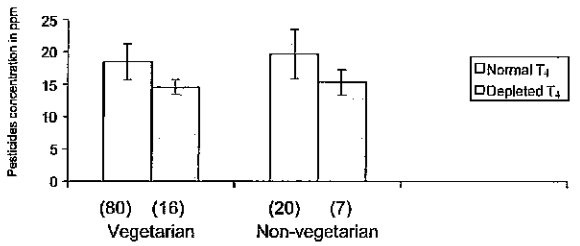

Fig. 2. Comparison of pesticide residue levels in female subjects having different dietary habits.

When a coefficient correlation was measured for dieldrin and T_4 values of all the hypothyroid subjects, it was found that there a low degree of negative correlation existed between them (Fig. 4).

4. Discussion

The results of the present study reveals that dieldrin was significantly high in all hypothyroid patients. Aldrin and dieldrin was traditionally used in agriculture to control soil insects as well as in

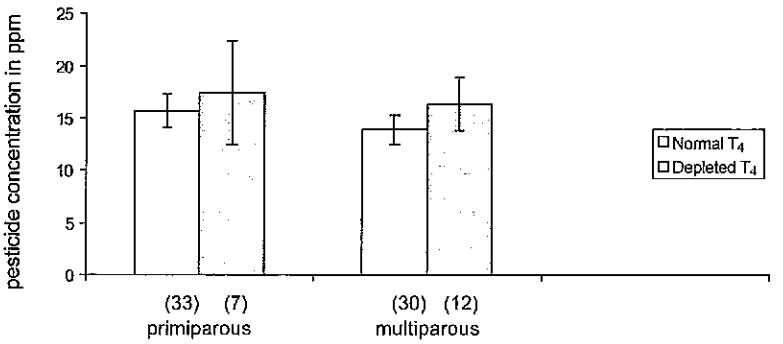

Fig. 3. Comparison of pesticide residue levels in primiparous and multiparous subjects.

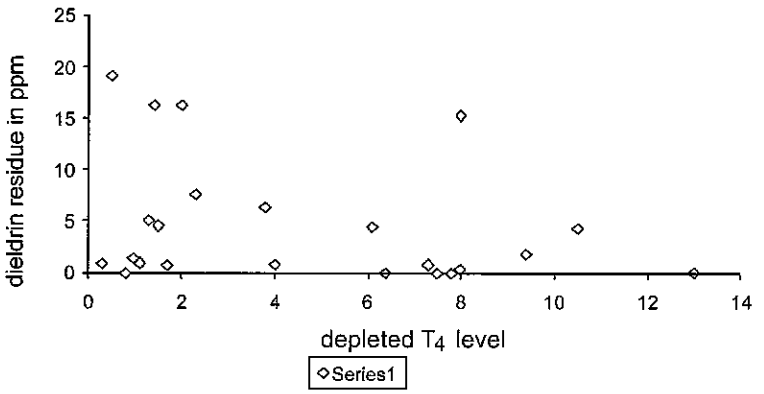

Fig. 4. Correlation between depleted T4 and dieldrin residue.

health protection programs. Primary uses today include controlling termites, woodborers and textile pests.

According to Fisher (1999), in plants and animals, aldrin is readily metabolized to dieldrin. Because it is persistent and hydrophobic, aldrin has been found to bioconcentrate in animal tissues mainly as dieldrin and its other conversion products. It is believed that the exposure of the general population to dieldrin is through food especially dairy products and animal meat. Furthermore, ingestion of contaminated fish and other food is also considered to be a likely route of human exposure (Maliwal and Guthrie, 1982; ATSDR, 1987; Fisher, 1999). As aldrin is converted to dieldrin in many organisms, the levels of dieldrin reflect the total concentration of both compounds. In a study conducted in 1992 in India and Vietnam on residues of persistent organochlorine compounds and their implications for human dietary exposure, it was calculated that the average daily intake of both aldrin and dieldrin was 19 μg per person in India, which exceeds the provisional tolerable daily intake of 0.1 μg/kg body weight, as recommended jointly by the FAO/WHO meeting on pesticide residues (JMPR) in 1977.

The results of the pesticide residues in different age groups suggest that women of lower age group had higher levels of pesticides. These results are in accordance with Kaphalia et al. (1985), which suggest that lower age group people face a higher risk of potential health hazards due to pesticides than those of higher age group. They also reported that vegetarian and non-vegetarian diets of this age group (11–20 years) were found to contain higher levels of organochlorine pesticides, as this is the growing age and the diet consumed during this age is also greater. Another important feature while considering the age group is that, in females, lactation and menses are considered as important means of disposing off such xenobiotics from the body, so females of a higher age probably have more chances to lose these compounds than females of lower age. According to Spicer and Keren (1993) and Czaja et al. (1997), lactation is one of the most important means of excreting organochlorine pesticides from the woman's body. However, Greve and Van Zoonen (1990), Gomez-Catalan et al. (1991) and Bates et al. (1994) reported an increase in organochlorine compound concentration along with the age.

It was further observed that women coming from semi-urban areas had higher pesticides residues. Although people living in urban and semi-urban areas might not be directly exposed to them, they may be indirectly exposed through the ingestion of contaminated water and food, especially the meat and poultry that are readily available to them. Schecter et al. (1997) reported that the serum levels of *p,p'*-DDT and *p,p'*-DDE were approximately three-fold higher among the urban population than among the rural population.

In this study, the subjects consuming a non-vegetarian diet had slightly elevated levels of

pesticides, probably because these organochlorines being lipophilic accumulates in the fat, and thus, there is a higher amount of these pesticides in animal meat that is consumed by man. Higher quantities of organochlorines in non-vegetarian diet have also been reported by Rodriguez et al. (1997) and Kashyap et al. (1994). Egg, meat and fish were analyzed in Jaipur City during 1992–1994 by John et al. (1995) and most of the samples were found to be contaminated with residues of *p,p'*-DDT, *p,p'*-DDD and *p,p'*-DDE, isomers of HCH (α, β, γ,), aldrin, heptachlor and heptachlor epoxide.

The residue analysis of blood samples of these subjects revealed that primiparous euthyroid and hypothyroid women had slightly higher levels of pesticides than all the multiparous subjects. Although the difference was not statistically significant. It is expected that older women should have higher concentrations of pesticides, but as in females, the maximum excretion of organochlorine pesticides is through lactation (Spicer and Keren, 1993; Czaja et al. 1997), in multiparous females, with each consequent delivery, these pesticides were probably shed. However, Krauthacker (1992) reported that there is no difference between the organochlorine levels in the primiparous and multiparous females.

The high levels of organochlorine pesticides, particularly dieldrin in hypothyroid women, suggest that these pesticides might be influencing the thyroid hormone status in the body as the T_4 levels in these subjects were low and TSH values were high, resulting in a hypothyroid state. Also, the correlation analysis reveals a low degree of negative correlation between T_4 values and dieldrin in hypothyroid women, suggesting that the high levels of pesticides might be responsible for the depleted T_4 values in these subjects. McClain (1992) and Kohn et al. (1996) have reported that chemicals can alter thyroid function and result in hypothyroidism through a variety of intrathyroidal and extrathyroidal mechanisms. Danowski et al. (1964) and Wassermann et al. (1971) have reported altered thyroid function as a result of exposure to organochlorine compounds in humans. Furthermore, Capen (1992) has mentioned chlorinated hydrocarbons (chlordane, DDT and PCBs) and polybrominated biphenyls (PBBs) as goitrogenic chemicals that disrupts thyroid hormone economy.

A number of studies reveal that structural similarities exist between chlorinated compounds and thyroid hormones. Also, due to structural similarities with thyroid hormone, certain PCBs, organochlorines and their metabolites affect thyroid function in rodents by competitively binding to transthyretin, and thus reducing circulating T_4 concentration (Brouwer and Van den Berg, 1986; Lans et al., 1993; Darnerud et al., 1996). Van den Berg (1990) reported that few DDT-like chemicals, such as *p,p'*-DDD, *o,p'*-DDD and dicofol interact with thyroid hormone carriers. Van den Berg et al. (1991) further reported that a variety of halogenated pesticides with different chemical structure are able to interact with thyroxine binding sites that lead to alteration in thyroid hormone homeostasis in man and experimental animals resulting in reduced plasma hormone levels and increased levels of TSH through feed back regulatory mechanism of the pituitary thyroid axis. In man, *o,p'*-DDD has been found to lower serum bound iodine by intervening with a thyroid hormone carrier (Marshall and Tompkins, 1968). Studies on human mothers and their offspring suggest that humans are sensitive to changes in thyroid hormone homeostasis, which is caused by chlorinated hydrocarbons, particularly PCBs, dioxins and organochlorine pesticides (Plium et al., 1993; Koopman-Esseboom et al., 1994; Ilsen et al., 1996; Fiolet et al., 1997; Nagayama et al., 1998).

In view of the significant role that the thyroid hormone plays in brain maturation in man and in other species, alteration in thyroid hormone levels and metabolism caused by chlorinated hydrocarbons may also lead to abnormal brain development (Rogan et al., 1988), while in adult subjects, hypothyroidism may affect brain function to cause behavioral symptoms, such as depression, paranoia and sleepiness.

Thus, the occurrence of organochlorines like DDT, HCH, dieldrin and heptachlor in the blood of the general population confirms the exposure of these people to pesticides. Food is considered to be the main source of organochlorine pesticide residues in the human body, accounting for 80–90% of their total dietary intake (Morgan and

Roan, 1974). Opportunities to gather more information on human experience associated with pesticide exposure must be more aggressively identified and pursued. Only with better human data will the risk assessment process warrant greater reliance in decision making concerning our chemical exposures and human experience.

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Department of Science and Technology, Jaipur.

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