DISCUSSION. AND SUMMARY
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Persistant chlorinated group of insecticides are still in use in the country in sufficient quantities both in agriculture and public health. The overall consumption of HCH is (25,000 tonnes) being the maximum out of this group of insecticides. Unintended side effects of pesticides particularly by the persistant type in the environment can be many fold (Blaszky, 1972). In contrast to acute toxicity hazards which are more alarming in reality, the problem of great concern with these insecticides is regarding secondary and cummulative effects which is predominantly due to entry of these chemicals into the body of living organism through food cycle (Kraybill, 1969). Magnification of concentration of these chemicals in organisms and food chains may primarily be in form of harmless residues which consequently become of toxicological significance (Hunt, 1966; Eichler, 1969; Spencer, 1971).

Our results of pesticide (HCH) residues in human body tissues and in food show a good deal of accumulation of this insecticide in our population. On the basis of our observations in prepared meals the average daily intake of this chemical (0.85 μg/kg bw/day) is comparatively on higher side than that
reported for other countries like U.K., U.S.A., and Japan (Abbott et al, 1969; Duggan and Corneliussen, 1972; Kojima, 1972). The residues in raw food commodities have too, shown a wide spread contamination. In majority of samples these residues are more than the permissible levels reported by international agencies like W.H.O., (1968, 1972, 1974). These observations have sufficiently established that the environmental contamination due to HCH has already reached to a stage which can pose a potential risk to the health of the people particularly if allowed to be continued unchecked.

The high degree of environmental pollution from chemical pesticides in our country predominantly seems to be due to injudicious use of these chemicals as can be born by the fact that the consumption of pesticides in our country (560 g/ha) is very less in comparison to consumption figure from West Germany and U.S.A. (3000 g/ha) and Japan (11,800 g/ha) (Prasad, 1976) where it can be presumed on the basis of residues data that the problem is of not so great concern as to us.

Under these circumstances, it is very much desirable that we should monitor the health of the people occupationally exposed to these chemicals during manufacture, formulation and application because these groups of individuals are exposed almost continuously for the entire working life to a sufficiently high concentration, in addition to body burden through environmental contamination. This aspect has been examined in details.
by studying 464 malaria spraymen exposed to HCH and 96 formul-
ators exposed to combination of pesticides.

Our observations on short term and long term exposure of HCH on 464 malaria spraymen exposed to HCH for varying period from 1 to 3 seasons or more have shown that the accumulation of HCH in their blood is almost 5 to 10 times depending upon the duration of exposure. The significance of these higher residues may not be of great concern at present in the absence of any marked illness in these spraymen but it cannot be completely overlooked particularly when it has been proved that high accumulation of these insecticides including HCH are carcinogenic in experimental animals (Nagasaki et al, 1971; Thorpe and Walkar, 1973; Nagasaki et al, 1975).

The spraymen and formulators have shown abnormalities in biochemical tests undertaken by us to determine early changes in health impairment particularly liver functions which is the target organ for this chemical. The results of S.G.P.T., alkaline phosphatase and LDH in spraymen and formulators when viewed in comparison to control subjects have shown that there is no marked derangement in the body organ function tests. However, the slight but significant deviations in these tests as compared to controls has made us to believe that there is positively an impact of this chemical on liver although it is difficult to presume at this stage whether these biochemical changes represents compensatory body response or early functional impairment.
Other workers have also put forward similar views (Tocci et al, 1969; Jager, 1970).

These observations in exposed spraymen and formulators in the form of higher residues, minimal changes in biochemical parameters in the absence of marked illness and haematological abnormalities have made it clear that there is a need of continued surveillance of workers exposed to HCH and efforts are needed at least to minimise this exposure. This can be achieved by proper supervision of workers during work and use of personal protective devices particularly clothings which will eliminate the skin absorption which is of primary concern during all work situations.

The environmental monitoring and human surveillance studies undisputably are of prime importance in establishing the suitability or otherwise of any economic chemical like pesticides. Even then there is always need to undertake laboratory animal experimental studies to provide in depth information about the various aspects of toxicity of these chemicals. Both human surveillance and animal experimental studies should be complementary to each other for scientific evaluation and solve the problems caused by these chemicals which have been regarded as amongst the worst environmental pollutants.

Animal experimentation undertaken by us to study the acute and subacute toxicity of HCH, the accumulation and distribution of residues in body (fat, liver and blood) and

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influence of HCH in relation to exposure to other group of insecticides mainly the organophosphate compounds (Malathion) are in corollary to our field studies in human beings. These observations in rats exposed to HCH at dose levels from 100 to 500 mg/kg have shown that HCH is moderately toxic chemical (LD₅₀ 646 mg/kg). The main toxic manifestations are due to effects on central nervous system.

The distribution of HCH and its isomers residues in rats fed at 500 ppm mixed in diet at interval of 2 weeks up to 12 weeks have shown gradual accumulation of the chemical. This accumulation in fat, liver and blood is not proportional to the duration of exposure. The peak concentration in fat reached at 10 weeks interval and stabilized thereafter. However, in blood the stabilization took place much earlier i.e. from six weeks onwards. The residues in the liver were increasing till the end of the experimental period. These experimental observations on serum residues of HCH in relation to duration of exposure are in conformity to our observations on serum residues of malaria spraymen where also it was noted that after a certain period the residues are not in proportion to further exposure.

Some of the workers have advocated that blood residues are a good index of the overall body burden of pesticide exposure (Nachman et al, 1969; and Davies et al, 1969a and Radomski et al, 1971). However, our results have shown that residue levels more so in blood are to be interpreted very carefully
and should not be considered as the only valid index of exposure
to this chemical and other factors need to be given due weightage
i.e. history of exposure and biochemical changes which are
indicative of pesticide stress of body response to these chemicals.

It has been advocated for sometime that exposure to
organochlorine insecticides is quite likely to influence the
toxicity of organophosphorous compounds (Durhan, 1967; Menzer, 1970;
Triolo et al, 1970). This aspect of pesticide exposure needs
more thorough exploration in view of limitations and constraints
in field studies. The true nature of interaction between these
two main group of insecticides can be assessed in depth only
in laboratory animals. In our experiments HCH has shown positive
evidence to influence the toxicity of Malathion an organophos­
phorous insecticide as judged by inhibition of cholinesterase
enzyme activity in response to subsequent exposure to malathion.

In two sets of animals pretreated with HCH at different
dose levels (5 and 50 ppm) mixed in diet, the response to exposure
to malathion was quite variable. The effect is found to be
antagonistic and synergistic at low and high doses of HCH respect­
ively. The extrapolation of these experimental results to
workers occupationally exposed to combination of pesticides
should be made with caution at this stage. This has re-emphasized
the need for both experimental and human surveillance studies
as supplementary to each other for proper evaluation and solutions
to the problems of pesticides hazards in relation to human
health.
Summary:

The present human surveillance, environmental (food) monitoring and animal experimental studies have been undertaken to assess the magnitude of pesticide (HCH) pollution in our community, the health hazards in occupationally exposed workers and the risk to health for the general population.

1. Residues in human tissues and in food:

1.1 The results of residue analysis from seventy seven autopsy fat samples of either sex and between 5 and 60 years representing general population show accumulation of HCH and its isomers. The mean HCH residues (4.14 ppm) in our population is relatively high in comparison to reports from U.S.A. and West European countries. Out of the three HCH isomers, alpha, gamma and beta, the beta isomer is the most persistent and contributes about 85% in total HCH. The HCH residues increase with age. Males have higher HCH residues as compared to females.

1.2 The estimation of HCH residues in adipose tissue, blood, brain and liver have shown the concentration maximum in adipose tissue. Next in order are blood, liver and brain. The ratio of blood to fat (1:9) is relatively below than reported for other insecticides and is indicative of recent continued exposure to HCH.

1.3 The HCH and its isomers residues in raw food
commodities like wheat, rice, pulse, groundnut, meat and fish have been found to be above the permissible levels reported by W.H.O. for these commodities and are also comparatively higher than reported for other countries.

1.4 The average daily intake of HCH by an adult man (50 kg) on the basis of two meals per day has been found to be (0.35 μg/kg bw/day) which is also higher than reports from other countries.

2. Health hazards in Malaria Spraymen exposed to HCH:

2.1 Health hazards due to short and long term exposure of HCH have been evaluated in 464 malaria spraymen in comparison to 204 controls by undertaking clinical examination, haematological changes, biochemical changes especially liver function tests and serum residue analysis.

2.2 The results of medical surveillance do not show any marked abnormal clinical manifestations except some skin lesions, in few cases.

2.3 There are no significant haematological and biochemical changes in respect of liver function tests like S.G.P.T., alkaline phosphatase and total protein.

2.4 Malaria spraymen store about 5 times (0.32 mg/litre) HCH in their blood as compared to (0.07 mg/litre) in unexposed population. The built up of serum HCH residues due to one spray
operation lasting for about 16 weeks is more (5 times) in hitherto unexposed subjects than in persons with past exposure to HCH (3 times).

2.5 The serum HCH residues in relation to duration of exposure show a gradual rising trend upto group III (upto 3 seasons) only and afterwards a fall in Group IV is observed. This indicates that serum HCH residues are not in proportion to duration of exposure.

3. Health hazards in pesticide formulators:

3.1 The health status of 96 formulators exposed to HCH DDT and Malathion have been assessed in comparison to 60 non-exposed subjects by undertaking clinical and laboratory examinations on similar lines as in Malaria spraymen and by measuring the ChE enzyme activity.

3.2 The formulators manifest only generalized symptoms in the form of headache, nausea, vomiting and irritation of eyes and skin as compared to control subjects.

3.3 The exposed subjects show a significant depression in cholinesterase activity (30%) as compared to unexposed.

3.4 A significant increase in liver function enzymes, e.g. S.G.P.T., serum alkaline phosphatase and Lactic dehydrogenase activity have been observed in formulators as compared to control
subjects which is suggestive of liver involvement and these
tests can be employed as an useful parameter for the early
detection of health impairment.

3.5 In formulators there is an increase in clotting
and prothrombin time, indicating risk of bleeding disorders.

4. Acute and subacute toxicity studies in rats:

4.1 The acute and subacute toxicity of HCH have been
evaluated in experimental rats and HCH is found to be a moder­
ately toxic chemical (LD$_{50}$ 646 mg/kg bw).

4.2 The observations on liver function tests in rats
given HCH orally at doses of 100-500 mg/kg bw show a dose related
hepatic dysfunction. A significant increase in clotting and
prothrombin time has also been observed.

4.3 The accumulation and distribution of HCH and its isomers
in body tissues of rats fed on diet mixed with 500 ppm HCH has
been estimated with respect to duration of exposure at interval
of 2 weeks upto a period of 12 weeks.

4.4 There has been no relationship in the accumulation
of HCH residues in blood, liver and fat with duration of exposure.
The HCH residues reached the peak concentration in blood and
fat at 6 and 10 weeks respectively whereas the liver show a
continued accumulation till the end of experimental period.
5. Effect of HCH on malathion toxicity.

5.1 The relative toxicity of malathion has been evaluated in rats pretreated with 5 and 50 ppm of HCH mixed in diet for a period of 2 weeks by estimating the blood and brain cholinesterase enzyme activity.

5.2 The pretreatment of rats with HCH at 5 and 50 ppm levels has been found to influence the toxicity of Malathion.

5.3 Experimental rats kept on lower dose (5 ppm) show protection whereas in rats on higher dose level (50 ppm) an enhancement in toxicity of malathion is observed.