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DIETARY EXPOSURE TO PESTICIDE RESIDUES BY VARIOUS PHYSIOLOGICAL GROUPS OF POPULATION IN ANDHRA PRADESH, SOUTH INDIA

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ABSTRACT

Dietary exposure assessment of fifteen pesticide residues was done in Andhra Pradesh. Twelve commonly consumed foods including water, which were representative of the diet, were collected, processed as table ready and analysed for the presence of various Organochlorines, organophosphates and synthetic pyrethroids. All the samples were contaminated with one or more of the 15 pesticide residues and all of them were within the MRLs. DDT and its isomers, Chlorpyriphos and Cypermethrin were frequently detected in many of the food samples. The mean concentration of the pesticide residues ranged from 0.02 µg kg^{-1} to 5.1 µg kg^{-1} (fresh weight) in the analysed foods. When exposure assessments was carried out for different age, sex and physiological groups it was found that the estimates of daily dietary intakes of the analysed pesticide residues in the present study are much lower than the volative levels in all age groups that were computed.

Keywords: table ready foods, pesticide residues, dietary intake, physiological groups, risk

INTRODUCTION

Pesticides are a group of heterogeneous chemicals that have a significant economic and public health benefit by increasing the productivity of the crops and alleviating food and vector borne diseases. However, public concern has increased over potential adverse health effects of such chemicals in the form of cancers of various types, endocrine disruption, cytogenetic damage and effects on reproductive, neurological as well as immunological systems (FAO, 2007).

The widespread use of pesticides has led to frequent exposures in infants, young children, adults and pregnant women who are often identified as target groups for pesticide exposure assessment because of their susceptibility to possible neurological and neurodevelopment effects. Food has been recognized as main source of exposure to pesticide residues (Adachi and Okano, 2006). Total Diet Studies (TDS) are conducted world-wide, typically to measure the intake of chemicals by various physiological age groups. Further, the samples are processed as consumed before they are extracted and analysed. Thus, they take into consideration, the reduction of chemicals that degrade during processing at home and present the best available data to estimate the intake of pesticide residues from the diets of a given population.

At present, India is the largest producer of pesticides in Asia and ranks twelfth in the world in the use of pesticides with an annual production of 81647 MT (The Energy and Resource Institute India, 2012). The Indian pesticides industry is dominated by insecticides, whereas globally, herbicides and fungicides are the key segments (India Pesticide Industry, 2011). Andhra Pradesh is the first highest pesticide consuming state in India (Bharadwaj and Sharma, 2013). Although many Organochlorines are banned in India under the Central Insecticide Act, 1968, several persistent organic pollutants (POPs) as organochlorine residues are detected in many foods due to their persistent nature. Many studies were carried out in India on the contamination of raw agricultural food commodities with pesticide residues. However, there is a dearth of information on exposure assessment through pesticide residues among various physiological groups in India (Battu, et al. 2004).

In the present study, 22 foods in South India were identified as per the data from National Nutrition Monitoring Bureau (NNMB, 2006) from various food groups as most commonly consumed. Only 12 out of the 22 such most commonly consumed including water samples were analysed to determine the concentration of fifteen pesticide residues. The dietary exposure by different physiological groups of human population in Andhra Pradesh was calculated both at mean intakes levels and at "upper bound" intake levels, i.e. at 95th percentile intakes.

MATERIALS AND METHODS

STUDY DESIGN

It was a cross sectional study carried out on samples drawn purposively from various representative points.

SCREENING OF SELECTED FOODS

Twenty two foods which were most commonly consumed in the South Indian state of Andhra Pradesh were listed from various food groups in the order of consumption as per the data from National Nutrition Monitoring Bureau (NNMB, 2006). Water samples were also collected from various parts of the State to estimate the exposure through water, which is consumed and used for cooking purposes. Of the 22 most commonly consumed foods that were listed from various food groups only 12 foods viz., rice, red gram dhal, tomato, brinjal, potato, spinach, amaranth, mango, milk, buttermilk and water and which were reported to have shown the presence of the selected residues were only analysed in the present study. The consumption data for the 12 foods including water samples were selected for the analyses of fifteen pesticide residues and were used for calculation of exposure to pesticides residues.

SAMPLE COLLECTION

Sample collection was done from September 2008 to May 2009. Using multi-stage random technique, six districts were identified from three geographical regions of the state. In each of these six districts, 2 blocks were randomly selected. Each food item was collected from two markets of each block to evaluate the possible variation. The final number of samples for each food was 24 (12 procurement points X 2 samples).

The information about the areas of foods cultivation, local or imported, their transportation and storage conditions were obtained from the vendors through a questionnaire. The items which were not found in the selected procurement points were collected from the next nearest market place. The samples procured were immediately transferred to the laboratory. Non perishable and semi perishable items like rice, red gram dhal and potatoes were packed in sterile polyethylene zip-lock pouches and transported at ambient temperature. Perishable foods like milk and buttermilk were packed in sterile pouches and transported under frozen condition in ice boxes. Drinking water samples (mainly supplied from river Manjira through municipal supply) was collected from the homes of the respective procurement points in amber coloured glass bottles and kept in ice box. Leafy vegetables like spinach and amaranth were wrapped in sterile and wet jute mats as otherwise they become damp in vacuum zip lock packing. Most perishable samples like milk, buttermilk, mango, spinach, tomato were processed the following day. Samples like potato, rice, pulse, sorghum, brinjal which are less perishable were processed one day later.

PROCESSING OF FOOD SAMPLES

Individual foods were subjected to basic household cooking processes using de-ionized water and the foods were prepared as "table ready" without salt, oil and spices according to the Standard Operating Procedures (SOPs) for validating the time, temperature and processing in the laboratory conditions (Table 2). Stainless steel vessels, lids, ladles, knives and Poly Tetra Fluoro Ethylene (PTFE) chopping boards were used for processing the food samples. No detergent was used in washing the vessels in order to prevent chemical contamination. Hot running water already tested for the analytes was used for washing. The cleaned vessels were dried in oven and kept in aseptic conditions for use to avoid cross contamination. Water samples were analysed as collected. The cooked foods were cooled, weighed, homogenized and bottled in sterile PTFE wide mouthed containers. The homogenized samples were stored at -20° C till analysed.

METHOD OF ANALYSES OF PESTICIDE RESIDUES IN THE SELECTED FOODS

The selection of specific pesticide residues for analyses was based on the reported incidences of those residues in each of the foods selected for the study (Kumari *et al*., 2002, Kumari *et al*., 2003, Bhanti and Taneja, 2007, Jayashree and Vasudevan, 2007, Kumari, 2008, Chopra *et al*., 2011).

The fifteen pesticide reduces selected were HCH (alpha, beta, gamma and delta), DDT and its isomers (2'4 DDT, 4'4 DDT, 2'4 DDE, 4'4 DDE, 4'4 DDD, 2'4 DDD), endosulfan (alpha, beta and endosulfan sulphate), chlorpyriphos and cypermethrin.

The foods were analysed individually, and not as composites, to check the contribution of each food to the exposure. Analyses of the residues were done using multi residue QuEChERS method (Anastassiades and Lehotey, 2003) and were quantified by gas chromatograph (GC) (Varian 3800 Gas Chromatograph) equipped with an Electron Capture Detector (ECD). The peaks eluted were confirmed by comparing the results of mass spectra of substances from food sample spectra to those of standard compounds selecting specific ions obtained from an ion trap detector, and Turbomass using GC/MS, (M/s. Perkin Elmer Ltd.) auto system.

For extraction, 8 g of the cooked wet food was taken and added with equal volume of 1% acetic acid in acetonitrile and subsequent extraction and clean up was done using Primary Secondary Amine SPE cartridges (Supelco, 595 North Harrison Road, Bellefonte PA, USA). The extract was concentrated under the continuous flow of dry nitrogen gas and made up using 1mL of hexane/acetonitrile for injection in to GC.

To determine the efficacy of the method in terms of the extraction and instrument validation, recovery studies were performed on 10 spiked replicates of blank food samples at concentrations 100, 75, 50 and 25 µg kg^{-1} (n=3 for each concentration) for all the pesticides residues analysed in the study using GC and found the recoveries ranged from 80-85% with the coefficient of determination

(R2) for the instrument being 99.99% between injections (n=6). The lowest limit of detection (LLOD) for the selected pesticide residues among all the samples studied on GC ECD was 1.0 µg kg^{-1}, for total Cypermethrin and it was 50µg kg^{-1} for Chloropyriphos. To maintain the quality control, a pure standard was run for a set of ten samples to know the retention times of the residues and solvent blank was injected to check carryover and interference contributing from the solvent used for reconstitution of residues.

GC OPERATING CONDITIONS

Make: Varian Analytical Instruments, California, USA.
Model: CP 3800 Gas Chromatograph
Detector: Electron Capture Detector (ECD)
Detector temp: 300ºC
Column: 5%phenyl 95% methyl polysiloxone column was used with internal diameter of 0.53 mm, thickness of 0.50 mm and with 30 m length with split less system.
Carrier gas: Iolar-1 nitrogen (99.999% purity)
Flow rate: 1.5 ml/min.
Oven Temp: initial 100º C (held for 2 min); to 190º C with ramping @ 5ºC per min (held for 5min); 250º C (held for 4 min) 35 min; Injector port temp: 270ºC.

DIETARY EXPOSURE

The dietary exposure to the pesticide residues was calculated based on the consumption data (amount or quantity of the food consumed by the various physiological groups) and contaminant data (the mean concentration of the pesticide residues expressed as µg kg^{-1} of the analysed foods). Estimates of exposures were calculated by multiplying the concentration of the pesticide residues in a food with the amount of that food consumed. The concentrations present in the cooked foods were added to the levels present in the amount of water needed for cooking the particular food stuff for calculating the dietary exposure to the contaminants**.** This gave the final exposure of the contaminants from the diet as a whole. Finally, the exposures were expressed as µg kg^{-1} body mass per day which were compared with the ADIs (FAO, 1996). In the present study, the mean concentrations of the pesticide residues were considered for calculating the exposures at mean and 95th percentile ingestion levels. To assign a numeric value to the contaminant concentration, the levels which were below the LOD were taken as 0 and for those between the LOD and LOQ were taken as the value of LOD. This was the lower bound estimate method given by (WHO, 1995).

RESULTS AND DISCUSSION

PESTICIDE RESIDUES CONCENTRATIONS

All the samples showed one or the other of the 15 pesticide residues. However, among the pesticide residues that were analysed, synthetic pyrethroid, cypermethrin was detected in highest concentration in all the samples. The maximum concentration of cypermethrin detected was 13.7 µg kg^{-1} and the mean concentration was 2.73 µg kg^{-1} in rice procured from Ramavaram Mandal of East Godavari District, while in Spinach the maximum concentration detected was 9.00 µg kg^{-1} and it was 5.1 µg kg^{-1}. More than 60% of samples of mango, milk and spinach also showed high amounts of residues of cypermethrin compared to the other foods. The second highest concentration of pesticide residue detected was an organophosphorus pesticide residue viz., chloropyriphos in water. Higher concentrations of g-HCH, Chlorpyriphos, 2'4DDE and Endosulfan sulphate were detected in water than in food samples. Either DDT or its derivates were found in one or the other foods tested. The mean concentration of total DDT was highest in milk (1.778 µg kg^{-1} fresh weight) followed by brinjal (1.76 µg kg^{-1} fresh weight) and the lowest mean concentration (0.061 µg kg^{-1} fresh weight), was detected in potato. Endosulfan sulphate was found to have detected at Below the Detection Limit in many of the foods. Isomers of Hexa Chloro Hexane (HCH - α, β, γ and δ) were found above the detection levels in all the foods (Table 3).

None of the samples tested without processing (mango and water), exceeded the MRL values given by Food Safety and Standards Authority of India (FSSAI, 2011). The concentrations in cooked foods were also less than the MRLs, suggesting that basic household processing does alleviate the concentration of residues (Ramesh and Balasubramanian, 1999).

DIETARY EXPOSURE ASSESSMENT

Dietary exposure to a specific contaminant is dependent on the quantity of food consumed, which varies with age. To assess the risk at different quantities of foods consumed and their intakes with respect to the age and physiological groups as given by National Nutrition Monitoring Bureau (NNMB 2006) which were considered for calculation were 1-3 years, 4-6 years, 7-9 years, 10-12 years (boys and girls), 13-15 years (boys and girls), 16-17 years (boys and girls), Sedentary worker (Male and female) and pregnant women. The estimates were calculated both at mean intake and at upper bound intake levels., i.e. at 95th percentile intakes.

Dietary intake of 15 pesticide residues detected was well below their respective Acceptable Daily Intakes (ADIs). However, in recent times there has been a concern regarding the application of the ADIs generated based on adult body weight of 60 kg to children, hence, while extrapolating the ADIs to children, it was further reduced by ten times. Even with such a calculation the exposure did not exceed the ADIs for any of the pesticide residues in any of the age and physiological groups both at mean and 95th percentile intakes (Tables 4a, 4b, 5a and 5b).

The World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) are in the forefront of the development of risk-based approaches for the management of public health hazards in food (WHO, 2012).

Table 1: Intake of various foods (g) at mean and 95th percentile levels in different age and physiological groups in Andhra Pradesh in 2006

Age Group	1-3 yrs (N=176)		4-6 yrs (N=178)		7-9 yrs (N=215)		10-12 yrs (N=102)		13-15 yrs (N=97)		16-17 yrs (N=47)		Sedentary Worker (N=343)		Pregnant Women (N=21)	
Foods	**Mean**	**95th**	**Mean**	**95th**	**Mean**	**95th**	**Mean**	**95th**	**Mean**	**95th**	**Mean**	**95th**	**Mean**	**95th**	**Mean**	**95th**
Cereals	172 ± 92	340	243± 101	455.5	279± 120	540.0	347± 131	565.45 (B) 589.95 (G)	440± 164	745.00 (B) 543.00 (G)	510± 164	836 (B) 644.60 (G)	426± 155	689.6 (M) 600.8 (F)	401± 149	659.3
Pulses	12 ± 15	37.2	18± 18	55.25	22± 24	75.2	22± 25	75.85 (B) 71.45 (G)	23± 25	68.08 (B) 70.00 (G)	37± 55	123.7 (B) 95.08 (G)	32± 34	92.46 (M) 86.4(F)	14± 29	97.70
Spinach and Amaranth	1± 6	5.2	3± 10	25.25	4± 14	27.28	6± 20	45.70 (B) 29.37 (G)	9± 28	68.44 (B) 28.05 (G)	7± 16	39.18 (B) 40.07 (G)	7± 19	40.52 (M) 32.34 (F)	14± 27	93.50
Tomato and Brinjal	11± 19	47.4	19± 29	88.05	22± 33	99.20	27± 41	116.11 (B) 114.55 (G)	30± 36	101.00 (B) 114.50 (G)	48± 54	159 (B) 119.4 (G)	41± 57	161.40 (M) 142.3 (F)	47± 44	125.7
Potato	12± 19	50.0	17± 22	69.35	21± 25	78.64	24± 26	76.80 (B) 88.22 (G)	30± 28	97.67 (B) 61.95 (G)	44± 52	182.2 (B) 91.26 (G)	39± 45	146.40 (M) 111.2 (F)	33± 43	161.3
Mango	33± 60	166.5	34± 59	194.25	39± 62	207	47± 88	186.35 (B) 235(G)	38±53	161.50 (B) 254.25 (G)	45± 55	186.4 (B) 175.5 (G)	44± 58	173.60 (M) 205.6 (F)	58± 80	260.9
Milk and Buttermilk	81± 105	298.5	77± 91	255.25	78± 106	356.2	82± 112	364.15 (B) 274(G)	71± 96	210.00 (B) 263.00 (G)	106± 94	284.8 (B) 308.1 (G)	139± 130	388.2 (M) 392 (F)	141± 198	652.2
Cooking Oil	7± 8	19.15	9± 6	22.02	12± 11	27.12	13± 11	30.87 (B) 31.3(G)	14± 8	29.2(B) 34.10 (G)	23± 22	57.40 (B) 36.89 (G)	20± 16	52.60 (M) 43.4 (F)	14± 8	34.1

Abbreviations: yrs: years; 95th: 95th percentile intake levels; b: boys; g: girls, source: NNMB report, 2006.

Total diet studies are recommended internationally as the most effective method for National exposure assessments (WHO, 2007). Such studies are essential in the developing countries where in presence of one or other persistent contaminants is encountered, even after imposing statutory bans. This further affects a great number of people as these countries also have a large population.

The Total Diet Study in Andhra Pradesh (APTDS) is first of its kind to have been conducted in India where, a total of 258 samples of food and water were analysed for 15 pesticide residues. None of the samples was free from pesticide residual contamination. Organochlorine pesticide residues; γ HCH, 4' 4 DDT and synthetic pyrethroid, cypermethrin were present in most of the foods analysed. Water samples were mostly contaminated with high levels of organophosphorus pesticide residues, chlorpyriphos.

However, the pesticide residues did not exceed the reference toxicological values (ADIs) in any of the age and physiological groups either due to dietary exposure or in their concentrations (MRLs) in cooked and raw foods.

The major drawback of TDS is the use of composites which do not indicate which food is the actual source of exposure to what level. Therefore, in the present study, foods were analysed separately and then categorised into similar groups. Cereal & millet group was the major contributor of total DDT, chlorpyriphos and total cypermethrin in all the physiological groups. This observation is significant in view of the fact that Andhra Pradesh is historically called the "The Rice Bowl of India" as it is one of the highest rice producing states of India. Rice is the staple food and is used/consumed in a wide variety of ways.

Milk was the major contributor for γ HCH in 4-6 yrs (33%), 7-9 yrs (34%), 13-15yrs (27%), 16-17 yrs (30%) and pregnant women (26%). Equal contribution (32%) of milk & milk products and cereals & millets to the γ HCH exposure was observed in children of 10-12 years age group. Fruits and spices were among the other major contributors to the pesticides residues.

The study showed that the exposure to total DDT is far less than the ADIs in all the age groups ranging from 0.01-0.03% of ADIs. These values are far less than the average value of 0.4% of ADI found in Canadian TDS during 1998 (Rawn *et al*., 2004). Also the values of γ HCH and chlorpyriphos were 0.13% and 0.08% of ADI, respectively; in Canadian population during the same period while these values in Indian populations were lower ranging from 0.003 to 0.1% and 0.02% of ADI, respectively. Highest intakes of chlorpyriphos and total DDT was found in children of age group 1-3 yrs in India and in 2-3 months age group in Canadian children.

Although, mango and amaranth were contaminated with a large number of pesticide residues, some even at high levels, the exposure is lower than the other foods as they are consumed in smaller quantities.

The detection of banned pesticide residues like DDT and its isomers/derivatives was not surprising and it is hypothesized that they, being organochlorines, have a longer persistence in the environment.

Table 2: Methods adopted for processing the foods

S. No	Food	Method of Processing
1.	Rice, raw, milled	Boiled in distilled water
2.	Red gram dhal	Boiled in distilled water
3.	Groundnut oil	Analysed as it was
4.	Buffalo milk	Boiled and analysed
5.	Butter milk	Analysed as it was
6.	Tomato	Washed with distilled water, chopped and boiled in water
7.	Brinjal	Washed with distilled water, sliced and boiled in water
8.	Potato	Washed with distilled water, boiled in distilled water and peeled off the skin
9.	Mango	Washed with distilled water, peeled, sliced and mashed and used
10.	Amaranth	Washed with distilled water dried overnight, chopped and boiled
11.	Spinach	Washed with distilled water dried overnight, chopped and boiled

The collection of the food samples was done in summer and winter seasons and there was no difference in the concentrations of the pesticide residues between the different seasons. The samples were not collected in rainy seasons; therefore, the effect of rains on the occurrence of pesticide residues could not be assessed.

The results of the study reveal that the dietary exposure to the contaminants investigated is much lower than the Acceptable Daily Intake in all the age groups that were computed. In specific cases, where the concentration of contaminants was high or where the consumption of a particular food was high, the exposures were also found to be higher but with in ADI.

Risk assessment in vulnerable population like pregnant women should be done accurately as even the lowest concentration of the organochlorine pesticide residues, which was still found to be persisting in the diets may have detrimental health hazards.

As the study is limited to rural areas, and processed foods like jams, jellies, noodles, pizzas, burgers, puffs etc. also need to be investigated and analysed for exposure assessment in near future.

Table 3: Concentration of pesticide residues in foods (µg kg^{-1} fresh weight)

Pesticide	Amaranth	Brinjal	Buttermilk	Mango	Milk	Potato	RGD	Rice	Spinach	Tomato	Water	G oil
a-HCH	0.04 (0.12)	0.21 (0.49)	0.023 (0.08)	0.57 (0.29)	0.83 (0.67)	0.03 (0.16)	BDL	1.42 (6.4)	0.007 (0.03)	0.28 (0.47)	BDL	0.98 (0.63)
b- HCH	0.11 (0.24)	0.22 (0.57)	0.18 (0.54)	2.32 (1.83)	BDL.	0.01 (0.040	0.043 (0.21)	0.13 (0.64)	0.064 (0.17)	0.27 (0.91)	BDL	0.44 (0.59)
g- HCH	0.5 (0.67)	0.16 (0.59)	0.30 (0.39)	0.35 (0.28)	0.65 (0.71)	0.13 (0.41)	0.093 (0.29)	0.029 (0.11)	0.048 (0.08)	0.048 (0.20)	0.89 (1.81)	0.55 (0.39)
d- HCH	0.14 (0.26)	0.04 (0.20)	0.018 (0.08)	0.75 (0.48)	0.5 (0.28)	BDL	0.048 (0.13)	0.25 (0.77)	0.303 (0.53)	0.063 (0.23)	0.1 (0.27)	0.36 (0.34)
Chlorpyriphos	0.29 (0.81)	0.21 (0.54)	0.12 (0.35)	1.01 (1.14)	1.55 (0.7)	0.25 (0.50)	0.32 (0.63)	0.27 (0.63)	BDL	0.17 (0.36)	1.027 (2.16)	0.83 (0.32)
2`4 DDE	0.13 (0.33)	0.11 (0.17)	0.25 (0.14)	BDL	0.1 (0.06)	0.013 (0.06)	0.28 (0.66)	0.033 (0.16)	0.13 (0.23)	0.046 (0.11)	0.338 (0.33)	BDL
a-Endosulfan	0.38 (1.51)	0.37 (1.62)	0.214 (0.25)	0.42 (0.49)	0.3 (0.14)	0.055 (0.16)	0.32 (0.98)	0.19 (0.59)	BDL	0.052 (0.24)	0.016 (0.06)	0.12 (0.18)
2'4 DDD	0.04 (0.06)	0.02 (0.06)	0.05 (0.09)	BDL	BDL	0.015 (0.04)	BDL	0.056 (0.23)	BDL	0.017 (0.04)	0.029 (0.11)	BDL
b-Endosulfan	BDL	0.27 (1.19)	0.068 (0.080	0.467 (0.31)	0.157 (0.11)	0.004 (0.02)	0.007 (0.03)	0.239 (0.46)	BDL	0.013 (0.04)	0.143 (0.32)	0.133 (0.24)
4'4 DDD	0.17 (0.69)	0.12 (419)	BDL	0.5 (0.14)	BDL	BDL	0.01 (0.04)	0.082 (0.27)	BDL	0.186 (0.64)	0.173 (0.25)	0.404 (1.8)
2'4 DDT	0.02 (0.09)	0.12 (0.407)	0.075 (0.15)	BDL	0.9 (0.71)	BDL	BDL	0.015 (0.06)	BDL	BDL	0.071 (0.24)	BDL
Endosulfan Sulphate	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.23 (0.69)	BDL	0.021 (0.07)	0.439 (1.19)	BDL
4'4 DDT	0.01 (0.05)	1.09 (0.13)	1.2 (2.4)	1.043 (0.34)	0.778 (0.32)	0.028 (0.09)	0.064 (0.18)	0.204 (0.36)	0.128 (0.17)	0.047 (0.09)	0.322 (0.41)	0.083 (0.19)
4'4 DDE	BDL	0.3 (0.02)	BDL	BDL	BDL	0.005 (0.02)	BDL	0.419 (1.68)	BDL	0.011 (0.03)	BDL	BDL
Cypermethrin	3.96 (3.02)	1.25 (1.68)	BDL	3.604 (2.37)	2.967 (2.01)	1.028 (1.02)	0.514 (0.72)	2.737 (6.12)	5.1 (3.05)	BDL	2.973 (2.73)	3.63 (3.29)

abbreviations: µg kg^{-1} , micrograms per kilogram of the food; BDL: Below Detection Limit; RGD, Red Gram Dhal, G oil, Groundnut oil;

values are represented as mean and figures in the parenthesis are Standard Deviations (SD), LLOD (GC-ECD) =1ng g^{-1}; LLOD (GC/MS) = 5ng g^{-1}

Table 4a: Estimated daily intakes of the target pesticide residues at 95th percentile food intake levels (µg kg^{-1} body mass/day)

Contaminant	1 - 3 yrs		4 – 6 yrs		7 - 9 yrs		10 - 12 yrs B		10 - 12 yrs G		13 - 15 yrs B	
	µg kg^{-1} body mass/day	%ADI	µg kg^{-1} body mass/day	%ADI	µg kg^{-1} body mass/day	%ADI	µg kg^{-1} body mass /day	%ADI	µg kg^{-1} body mass/day	%ADI	µg kg^{-1} body mass/day	%ADI
a- HCH	0.154	0.307	0.124	0.248	0.105	0.210	0.083	0.166	0.084	0.169	0.047	0.094
b- HCH	0.048	0.095	0.037	0.075	0.029	0.059	0.022	0.043	0.025	0.050	0.013	0.027
g-HCH	0.029	0.059	0.020	0.039	0.018	0.035	0.014	0.028	0.013	0.025	0.008	0.015
d- HCH	0.045	0.090	0.034	0.068	0.029	0.058	0.022	0.045	0.022	0.045	0.013	0.025
Chlorpyriphos	0.083	0.829	0.058	0.582	0.051	0.513	0.040	0.398	0.037	0.374	0.021	0.208
2`4 DDE	0.011	0.109	0.009	0.085	0.008	0.078	0.006	0.062	0.006	0.056	0.003	0.029
a-Endosulfan	0.036	0.061	0.029	0.048	0.025	0.041	0.020	0.033	0.019	0.032	0.011	0.018
2'4 DDD	0.005	0.055	0.005	0.045	0.004	0.038	0.003	0.031	0.003	0.031	0.002	0.018
b-Endosulfan	0.033	0.055	0.026	0.044	0.022	0.037	0.017	0.029	0.018	0.030	0.010	0.016
4'4 DDD	0.016	0.157	0.013	0.131	0.011	0.105	0.008	0.082	0.009	0.089	0.007	0.067
2'4 DDT	0.025	0.245	0.014	0.142	0.014	0.137	0.011	0.107	0.008	0.084	0.005	0.051
Endosulfan Sulphate	0.020	0.331	0.017	0.280	0.014	0.235	0.011	0.187	0.012	0.195	0.011	0.181
4'4 DDT	0.064	0.639	0.044	0.440	0.038	0.385	0.030	0.295	0.028	0.281	0.019	0.194
4'4 DDE	0.036	0.361	0.031	0.306	0.026	0.256	0.020	0.204	0.021	0.212	0.020	0.197
Cypermethrin	0.378	0.756	0.304	0.608	0.256	0.513	0.205	0.410	0.204	0.409	0.175	0.350

Abbreviations: yrs: years; b,: boys; g: girls; µg kg^{-1} body mass/day, micrograms per kilogram body mass per day; ADI: Acceptable Daily Intakes. FAO (1996).

Table 4b: Estimated daily intakes of the target pesticide residues at 95th percentile food intake levels (µg kg^{-1} body mass/day)

Contaminant	13 - 15 yrs G		16 - 17 yrs B		16 - 17 yrs G		SW (M)		SW (F)		PW	
	µg kg^{-1} body mass/day	%ADI	µg kg^{-1} body mass/day	%ADI	µg kg^{-1} body mass/day	%ADI	µg kg^{-1} body mass/day	%ADI	µg kg^{-1} body mass/day	%ADI	µg kg^{-1} body mass/day	%ADI
a- HCH	0.058	0.117	0.072	0.143	0.057	0.113	0.059	0.118	0.057	0.114	0.059	0.117
b- HCH	0.019	0.038	0.016	0.032	0.014	0.027	0.014	0.027	0.015	0.031	0.016	0.033
g- HCH	0.009	0.018	0.009	0.018	0.008	0.016	0.009	0.018	0.010	0.020	0.013	0.026
d- HCH	0.016	0.032	0.017	0.034	0.014	0.029	0.015	0.030	0.015	0.031	0.018	0.035
Chlorpyriphos	0.027	0.268	0.028	0.282	0.024	0.245	0.027	0.267	0.028	0.279	0.034	0.336
2`4 DDE	0.004	0.039	0.005	0.048	0.004	0.041	0.004	0.043	0.004	0.043	0.005	0.052
a-Endosulfan	0.014	0.023	0.015	0.026	0.013	0.021	0.013	0.022	0.014	0.023	0.015	0.025
2'4 DDD	0.002	0.021	0.003	0.027	0.002	0.021	0.002	0.022	0.002	0.021	0.002	0.022
b-Endosulfan	0.013	0.021	0.014	0.024	0.011	0.019	0.012	0.020	0.012	0.020	0.012	0.021
4'4 DDD	0.007	0.066	0.007	0.066	0.005	0.054	0.006	0.056	0.006	0.058	0.006	0.059
2'4 DDT	0.006	0.060	0.006	0.057	0.006	0.058	0.007	0.069	0.007	0.075	0.011	0.106
Endosulfan Sulphate	0.008	0.133	0.010	0.171	0.008	0.132	0.008	0.135	0.008	0.128	0.007	0.124
4'4 DDT	0.020	0.203	0.020	0.198	0.018	0.178	0.019	0.192	0.021	0.205	0.025	0.251
4'4 DDE	0.015	0.145	0.019	0.187	0.014	0.144	0.015	0.147	0.014	0.139	0.014	0.136
Cypermethrin	0.143	0.287	0.166	0.333	0.135	0.270	0.142	0.284	0.140	0.281	0.157	0.314

Abbreviations: yrs: years; b: boys; g: girls; sw (m): sedentary worker (male); sw (f): sedentary worker (female); µg kg^{-1} body mass/day: micrograms per kilogram body weight per day; ADI: Acceptable Daily Intakes. FAO (1996).

Table 5a: Estimated daily intakes of the target pesticides using mean measured residue concentration at mean levels of food intake (µg kg^{-1} body mass/day)

Pesticides	1 - 3 yrs		4 - 6 yrs		7 – 9 yrs		10 - 12 yrs		Ref. ADI
	µg kg^{-1} body mass/day	% of ADI	µg kg^{-1} body mass/day	% of ADI	µg kg^{-1} body mass/day	% of ADI	µg kg^{-1} body mass/day	% of ADI	
g- HCH	0.007	0.14	0.0421	0.84	0.0034	0.007	0.00291	0.006	0.05
Chlorpyriphos	0.022	0.2	0.0168	0.2	0.014	0.14	0.012	0.12	0.01
2'4' DDE	0.0042	0.04	0.0028	0.03	0.0023	0.02	0.0019	0.02	0.01
2'4' DDD	0.0027	0.03	0.00023	0.002	0.0019	0.02	0.0033	0.02	0.01
4'4' DDD	0.0062	0.06	0.0044	0.07	0.0037	0.04	0.0033	0.03	0.01
2'4 DDT	0.0043	0.008	0.0022	0.02	0.0017	0.02	0.0014	0.01	0.01

Endoslfan Sulphate	0.098	0.2	0.089	1.5	0.008	0.12	0.0068	0.1	0.006
4'4 DDT	0.018	0.2	0.0134	0.1	0.0109	0.1	0.0094	0.09	0.01
4'4 DDE	0.018	0.2	0.0162	0.2	0.139	1.4	0.0012	0.01	0.01
Cypermethrin	0.157	0.4	0.1253	0.2	0.107	0.21	0.094	0.2	0.05
Abbreviations: yrs: years; b: boys; g: girls; µg kg^{-1} body mass/day: micrograms per kilogram body mass per day; ADI: Acceptable Daily Intakes. FAO (1996).									

Table 5b: Estimated daily intakes of the target pesticides using mean measured residue concentration at mean levels of food intake (µg kg^{-1} body mass/day)

Pesticides	**13 - 15 yrs**		**16 – 17 yrs**		**Sedentary Worker (Male)**		**Pregnant women**		**Ref.ADI**
	µg kg^{-1} **body mass/day**	**% of ADI**	µg kg^{-1} **body mass/day**	**% of ADI**	µg kg^{-1} **body mass/day**	**% of ADI**	µg kg^{-1} **body mass/day**	**% of ADI**	
g- HCH	0.0023	0.005	0.0025	0.005	0.0019	0.004	0.0028	0.006	0.05
Chlorpyriphos	0.010	0.1	0.011	0.11	0.0083	0.08	0.011	0.1	0.01
2'4 DDE	0.0017	0.02	0.0018	0.02	0.0018	0.02	0.0017	0.02	0.01
2'4 DDD	0.0016	0.02	0.0016	0.02	0.0014	0.01	0.0015	0.01	0.01
4'4' DDD	0.0029	0.03	0.0029	0.03	0.0032	0.03	0.0028	0.03	0.01
2'4 DDT	0.0011	0.01	0.0012	0.01	0.0004	0.004	0.0016	0.02	0.01
Endoslfan Sulphate	0.0064	0.1	0.0063	0.1	0.0068	0.11	0.0056	0.09	0.006
4'4 DDT	0.0079	0.08	0.0081	0.08	0.0054	0.05	0.0086	0.09	0.01
4'4 DDE	0.012	0.1	0.011	0.1	0.012	0.11	0.0010	0.1	0.01
Cypermethrin	0.087	0.2	0.086	0.2	0.0066	0.12	0.080	0.2	0.05
Abbreviations: yrs: years; b: boys; g: girls; µg kg^{-1} body mass/day: micrograms per kilogram body weight per day; ADI: Acceptable Daily Intakes. FAO (1996)									

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