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Endosulfan Toxicity in Vegetables Grown in and Around Ajmer and its Possible Effect on Human Health

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Abstract: India has a diverse edapho-climatic conditions and variety of soils on which a range of vegetable crops are grown. To combat with the pest infestation problem, farmer and vegetable cultivators uses a variety of pesticides on their crops. Endosulfan was one of the prime choices since long time for the farmer as an effective pesticide with low cost. The government of India has now banned the use of Endosulfan in agriculture sector since April, 2011. But due to cheaper option and high effectiveness, it is still being used illegally in agriculture sector as broad spectrum non systematic insecticide against insect pests on different vegetables. Pesticide safety is classified by the World Health Organization (WHO) according to the results of LD50 tests. Under this system, Endosulfan is currently classified as Class-II (moderately hazardous) to human health. However, the USEPA rates Endosulfan as category Ib (highly hazardous). The present study was focused on the determination of Endosulfan contamination in five selected vegetables grown in summer season in and around Ajmer city of Rajasthan state, India. The study was carried out for the year 2009 and 2010. The study reveals that Endosulfan level in 2009 in different vegetables were found in the range of 0.033 ppb (Kanas) to 8.487 ppb (Pushkar) in spinach, 0.277 ppb (Palbichla) to 5.611 ppb (Pushkar) in bottlegourd, 0.004 ppb (Makhopura) to 2.361 ppb (Palbichla) in okra, 0.041 ppb (Ramgang) to 0.597 ppb (Kotda) in roundgourd and 0.037 ppb (Kotda) to 0.725 ppb (Makhopura) in chilli. The average levels of Endosulfan residues in summer vegetables of 2010 were detected in the range varied from 0.029 ppb (Kanas) to 0.255 ppb (Khanpura) in spinach, 0.010 ppb (Budha pushkar) to 0.017 ppb (Palbichla) in bottlegourd, 0.197 ppb (Hokra) to 1.832 ppb (Khanpura) in okra, 0.032 ppb (Pushkar) to 0.035 ppb (Palbichla) in roundgourd, 0.016 ppb (Ramganj) to 0.038 ppb (Banseli) in chilli.

Key words: Endosulfan toxicity · Vegetables · Ajmer · LD50

INTRODUCTION

Agro-ecosystems are purely modified system characterized by tremendous channeling of food energy into human population [1]. Agriculture is the mainstay of Indian economy. The 1.01 billion population is dependent an agricultural commodities from 124.07 million ha of cropped area cultivated by 110.7 million farmers in India [2]. India is the third single largest consumer of pesticides in the world and highest among the South Asian Countries [3]. A large portion of pesticide consumption in Indian agriculture is shared by vegetable crops. Vegetable production has been rapidity increased in last two decades [4]. Vegetables play a significant role in human nutrition, especially as sources of vitamins, minerals and dietary fiber [5]. India also exports modest quantities of vegetables and fruits to the central Asia and European countries. During 2003-04, 97.50 mt vegetables were produced from 7.59 mha of total vegetable production area in India. Vegetables supply 16% of magnesium, 19% of iron and 9% of the calories [6]. Vegetables in the daily diet have been strongly associated with reduced risk for some forms of cancer, heart disease, stroke and other chronic disease [7,8]. Vegetables are strong antioxidant and functions to modify the metabolic activation and detoxification of carcinogens, or even influence processes that alter the course of the tumor cell [9].

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The yield of both vegetables and fruits are substantially reduced by infestation of various insect pests. The insect pests cause 35-40% losses to the yield and sometimes the losses are as high as 60-70% [10] Pesticides, an indispensable component of integrated pest management (IPM), can considerably reduce these losses when applied judiciously. High dependence on pesticides by untrained farmers has increased health hazards and polluted the rural environment. Chemical-based pest control programs have disturbed the agro-ecosystem and killed the non-target and eco-friendly organisms such as earthworms, parasitoids, predators and birds. Pesticide use poses a threat to farmers, children and women workers in fields who are at high risk of being poisoned. The chronic poisoning due to pesticide can cause adverse immune functions, peripheral neuropathies and allergic reactions, particularly of skin. The acute poisoning may vary from skin irritation to complex systematic illness resulting in death. Accidental exposure in houses from inapt storage of pesticides and poisoning caused due to the use of empty container of pesticides for carrying water is quite common.

The present research was focused on the assessment of contamination level of endosulfan in vegetables grown in summer season in and around Ajmer city. Endosulfan, an organochlorine pesticide, is a broad spectrum contact insecticide widely used in pest control. It is used in a wide range of crops including vegetables, cereals, coffee, cotton, fruit, oil seeds, potato and tea. There is a global concern over the acute toxicity of endosulfan. Technically endosulfan is a mixture of two isomers – alpha-endosulfan and beta-endosulfan a mixed proportion of 70% and 30% respectively. The endosulfan residues of toxicological concern are alpha-endosulfan, beta-endosulfan and endosulfan sulfate. The sulphate is regarded as being equally toxic and of increased persistence in comparison with the parent isomers [11]. The Industrial Toxicological Research Centre (ITRC) in India is the nodal centre for the Regional Based Assessment of Persistent Toxic Substances (PTS) for the Indian Ocean region by the United Nations Environment Programme-Global Environment Facility (UNEP-GEF) classifies endosulfan as Extremely Hazardous [12]. The Intergovernmental Forum on Chemical Safety (IFCS) identified endosulfan as an acutely toxic pesticide that poses significant health problems for developing countries and economies in transition [13]. According to the International Programme on Chemical Safety, the Acute oral LD50 (Lethal Dose) for rats is 80 mg/kg and the inhalation LC_{50} (Lethal Concentration) (1 hour) for rats > 21 mg/L in air. However according to the USEPA the LD_{50} for oral exposure is 30mg/kg and LC_{50} is less than and equal to 0.5mg/L.

Toxicity studies of Endosulfan have been conducted in animals. Animal toxicity studies are carried out to identify the target organs of toxicity and possible spectrum of effects. The effects of any chemical are determined by the dose, duration and the time of exposure. There is a close similarity between the spectrum of health effects observed in the human population exposed to endosulfan and those described in animal experiments. It has been demonstrated that much lower doses of toxicants may result in adverse health effects manifesting as functional or organic disorders in later life if the exposure takes place during the early developmental phase. Therefore, the objective of the present study was to assess the endosulfan residues in the summer vegetables grown in the Ajmer region.

Study Area: The study was conducted for the determination of pesticide contamination in summer vegetables grown in and Around Ajmer city (India), which lies between 26°25'-26°35' North latitude and 74°37'-74°42' East longitude. The samples of different vegetables were taken from ten selected sites based on production of vegetables. These sites were Palbichala, Kanas, Banseli, Ramganj, Hokra, Makhopura, Khanpura, Budha-Pushkar, Pushkar and Kotda. The region is located in the central Aravalli range. Ecologically, the region is interesting due to its situation at the confluence between north-west dry zone and south-east comparatively humid zone. The north-west part is sandy and unproductive while the south-eastern part is clay-loamy fertile and suitable for vegetable production. The climate of the region is semi-arid with strong seasonality of rainfall. The summer season (April to June) experiences high temperature (max. 45.7ºC), while in peak winters (December to January) it goes down very low (3.7ºC). More than 80% of 784.4 mm annual precipitation occurs during July to September.

MATERIALS AND METHODS

Samples are the true representatives of entire population or entity [14]. The samples of different vegetables were collected from selected sites. A total of 120 samples of vegetables from selected sites were taken for analysis. Fresh samples of vegetables were collected (1kg each) in triplicate from each farmer's field during summer seasons of 2009 and 2010. Vegetables collected for the present research were Spinach (*Spinacia oleracea*), Bottlegourd (*Lagenaria siceraria*), Okra (*Abelmoschus esculentus* L.), Roundgourd (*Citrulus vulgaris*) and Chilli (*Capsicum annum*). All the vegetable samples were collected when they were ready to be transported from agricultural fields to the local vegetable markets [15]. After the collection of samples, they were kept in polythene bags and transported to the laboratory on ice immediately after collection and were stored at 4°C until the analysis. Vegetable samples were then processed as described by Codex Alimentarius [16]. Collected samples of vegetables were extracted and analyzed for the presence of Endosulfan according to standard method with some modifications [17, 18].

Gas Liquid Chromatography Analysis: The residues of endosulfan was analyzed using a Chemito Gas Chromatograph (Model 8610) equipped with 63Ni ECD detector and BPX-608 capillary column (25m x 0.32 ID x 0.46µm). The standard operating conditions as per the manual were followed for the present investigation [19].

RESULTS AND DISCUSSION

The average levels of Endosulfan residues in vegetables of summer season of the 2009 were found in the range of 0.033 ppb (Kanas) to 8.487 ppb (Pushkar) in spinach, 0.277 ppb (Palbichala) to 5.611 ppb (Pushkar) in bottlegourd, 0.004 ppb (Makhopura) to 2.361 ppb (Palbichala) in okra, 0.041 ppb (Ramgang) to 0.597 ppb (Kotda) in roundgourd and 0.037 ppb (Kotda) to 0.725 ppb (Makhopura) in chilli (Table 1). The average levels of Endosulfan residues in summer vegetables of 2010 were detected in the range varied from 0.029 ppb (Kanas) to 0.255 ppb (Khanpura) in spinach, 0.010 ppb (Budha pushkar) to 0.017 ppb (Palbichala) in bottlegourd, 0.197 ppb (Hokra) to 1.832 ppb (Khanpura) in okra, 0.032 ppb (Pushkar) to 0.035 ppb (Palbichala) in roundgourd, 0.016 ppb (Ramganj) to 0.038 ppb (Banseli) in chilli (Table 2).

It was observed that majority of vegetable samples analyzed for Endosulfan were found under Not Detectable (ND) limits. Similar results were observed in earlier study,

Table 1: Endosulfan residues (ppb) in vegetable samples during summer season of 2009

	Spinach		Bottlegourd		Okra		Roundgourd		Chilli	
Sampling Site	AVE	SD	AVE	SD	AVE	SD	AVE	SD	AVE	SD
Palbichala	0.117	0.044	0.277	0.185	2.361	0.996	0.167	0.249	0.088	0.080
Kanas	0.033	0.020	ND	ND	1.525	0.542	ND	ND	ND	ND
Banseli	0.085	0.034	ND	ND	0.440	0.220	0.266	0.189	0.130	0.072
Ramganj	0.115	0.092	0.799	0.436	1.220	0.893	0.041	0.020	ND	ND
Hokra	0.284	0.252	ND	ND	0.250	0.161	ND	ND	ND	ND
Makhopura	ND	ND	3.974	1.763	0.004	0.002	0.564	0.360	0.725	0.454
Khanpura	ND	ND	ND	ND	0.143	0.081	0.139	0.099	ND	ND
Budha Pushkar	ND	ND	ND	ND	1.848	0.793	ND	ND	0.234	0.209
Pushkar	8.487	5.064	5.611	2.842	1.812	0.690	ND	ND	0.043	0.012
Kotda	0.162	0.108	2.556	1.347	0.535	0.311	0.597	0.550	0.037	0.026

* ND = Not Detectable

Table 2: Endosulfan residues (ppb) in vegetable samples during summer season of 2010

	Spinach		Bottlegourd		Okra		Roundgourd		Chilli	
Sampling Site	AVE	SD	AVE	SD	AVE	SD	AVE	SD	AVE	SD
Palbichala	0.100	0.063	0.017	0.012	1.715	1.143	0.035	0.024	ND	ND
Kanas	0.029	0.019	ND	ND	ND	ND	ND	ND	ND	ND
Banseli	0.068	0.045	ND	ND	0.400	0.268	ND	ND	0.038	0.025
Ramganj	0.090	0.057	ND	ND	0.789	0.526	0.033	0.022	0.016	0.011
Hokra	0.036	0.024	ND	ND	0.197	0.132	ND	ND	ND	ND
Makhopura	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Khanpura	0.255	0.160	ND	ND	1.832	1.158	ND	ND	ND	ND
Budha Pushkar	0.083	0.056	0.010	0.007	1.641	1.094	0.033	0.023	ND	ND
Pushkar	0.076	0.040	ND	ND	1.445	0.964	0.032	0.022	0.036	0.024
Kotda	ND	ND	ND	ND	0.492	0.328	ND	ND	ND	ND

* ND = Not Detectable

in which authors studied the residues and fate of endouslfan in pepper and tomato [20]. They further reported that the initial level of total residues (alpha, beta and Endosulfan sulfate) was higher in leaves than observed in the fruits. The fate of Endosulfan poisoning has been studied extensively by different researchers [21-24]. Similarly, organochlorine pesticide residues were monitored in summer and winter vegetables of Agra and concluded that majority of the vegetable samples are within their MRL values as per CODEX Alimentarious standards [25]. The results of the study are in accordance with the findings of earlier study, in which Endosulfan residues were assessed in different vegetables and the effect of washing, peeling and cooking on Endosulfan residues (ER) levels in winter vegetables (Spinach, cauliflower and potato) and summer vegetables (brinjal, tomato and okra) grown under controlled supervised filed trials. It was noticed that highest ER was found at raw stage in brinjal (2.43 mg/kg) followed by okra (1.83 mg/kg) and spinach (1.25 mg/kg) and lowest in potato (0.177 mg/kg) [26].

Similarly, the dissipation of Endosulfan residues from unprocessed and processed brinjal (*Solanum melingena* L.) was also carried out [27]. The results of the present study are in agreement with the findings of earlier studies [28-29]. They studied residues of organochlorine pesticides in fruits, vegetables and tubers. The reverse phase liquid chromatographic method for analysis of Endosulfan and its major metabolites were developed [30]. It was observed that levels of Endosulfan in vegetables were higher in different seasons in comparison to other organochlorine pesticides used in the region. It may be due to ease availability and absence of ban on the use of Endosulfan in India. However, the results of the present study are negating with the earlier findings, which was focused on lepidopteran pest management in cabbage [31]. The study was based on percentage of plant infested with lepidopteran pest complex in fresh market cabbage. They did not detected Endosulfan from any sample of cabbage because Endosulfan was banned in USA since long time. However, Endosulfan is extensively being used in India and thus, its levels are detected in almost all vegetable samples. Although, contamination of Endosulfan in different vegetable were found below the maximum permissible limit (MRL), except some of the samples collected from Pushkar in 2009. The probable reason of lower residues in summer may be due to high temperature and long day length for this season [32,33].

Nevertheless, continuous application of such organochlorine pesticide may leads to severe health related problems. However, in 2011 the government of India has put complete ban on the use of endosulfan in agriculture, which has curtailed the problem of endosulfan toxicity. But, because of cheaper option and high effectiveness, it is still being used illegally in agriculture sector as broad spectrum non systematic insecticide against insect of different vegetables. Due to longer persistence of endosulfan in the environment, it is still found in the environment. Thus, regular monitoring of endosulfan residues in vegetables are recommended to mitigate such malaise.

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