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PESTICIDE CONTAMINATION OF FRUITS AND VEGETABLES : RISK ASSESSMENT USING HEALTH EFFECT MODEL

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ABSTRACT

This paper reports the risk assessment of pesticide contamination of food and food products in India and other countries by applying EFSA health effect model. For this review study some reported data on pesticide contamination have been collected from different sources and EFSA model has been applied on these data to assess its health effects. In the safety assessments of EU maximum residues levels (MRLs) for pesticides, or proposals for MRLs, the chronic and acute dietary consumer exposure to pesticide residues is estimated by using a calculation model developed by EFSA (PRIMo – Pesticide Residue Intake Model). The model is based on national food consumption figures and unit weights provided by Member States and implements internationally agreed risk assessment methodologies to assess the short-term (acute) and long-term (chronic) exposure of consumers.

KEY WORDS : Pesticide, Chlorpyrifos, EFSA model etc.

INTRODUCTION

Toxicants are toxic substance which is generally made by human or introduced into environment by human activity. Toxicants are different from toxins which are toxic substances produced naturally by any living organism. In the total life cycle of an organism it can be exposed to different types of toxicants. These toxicants may enter into food chain and food web and its toxicity will be dependent on organism's placement within food chain or web.

If any area is affected by any toxicant it may eventually establish a trophic cascade and the bio magnification. But this affect is typically limited in affected areas. Many toxicants like insecticides, pesticides and fertilizers have harmful effect on organism which can reduce its specific diversity and abundance. Such changes in population dynamics affect the ecosystem by reducing its productivity and stability. Toxicants can come from both natural and human made sources and affect the human and environmental health and may find their way to food, water and air by different sources which includes organic and inorganic pollutants, pesticide and biological agents and can have harmful effect on living organism.

Pesticide means any substance use for preventing, attracting, repelling or controlling any pest including unwanted species of plants or animals during production, storage, transport, distribution and processing of food or agricultural commodities.The pesticide residue is a substance or mixture of substances in food, feed, soil, water and air originating from the use of pesticides and includes the specified degradation and conversion products, metabolites, reaction products and impurities (Dhaliwal, 2009).

Though toxicants come from many sources, they tend to move through the environment in certain ways. Toxicants may find their way into aquatic systems as they get carried away by runoff from large areas of land. Because the water systems are smaller than the land that supplied the contaminants, the toxicants tend to get concentrated in the water. Once in surface water, toxicants can leach down into groundwater and contaminate sources of drinking water. Many chemicals are quite water-soluble, which means that they are easily

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dissolved by water. Because most organisms need water, this also means that we are most susceptible to these toxicants. Pesticides threaten the flora and fauna of all habitats as it does not differentiate between targeted and non-targeted species due to its toxic nature (Wassemann, 1972). These highly stable compounds can last for years and decades before breaking down in the environment. Pesticides can be globally transported far away from the original sources through a repeated process of evaporation and deposit (Williams, 2000).

Pesticide use and contamination of food

Different anthropogenic activities are responsible for the release of most of the pesticides in the environment every year. These pesticides are lethal and are congenital for humans and animals. Mainly the pesticides act on the neurotransmitter of pests. If the pesticides contaminated food is used by the human being, then these pesticides can also attack on the neurotransmitter of human being. There is no differentiating characteristic of pesticides, to differentiate between pests and human beings (Neff, 2012; Strecct, 1981; Maroni, 1990) found that these pesticides can cause cancer, hypersensitivity, damage to the central and peripheral nervous systems, reproductive disorders, and disruption of the immune system.

Presently the world economy is based on its crop productivity and pests are main damaging agents of crops. The pre and post harvesting damage of crops is caused by pests. For this many pesticides are used, which serve the function of repelling and controlling the spread of these pests and results in increased crop production. Nevertheless, this resultsin the increased use of pesticides and their adverse effects also (Palikhe, 2001) anticipated that in developing countries, to increase the agricultural production their reliance on pesticide will steadily increase. This is further supported by the FAO's study report in which 4.5 percent of annual growth in pesticide use is reported in developing countries (Dahal, 1995).

Pesticide use in different countries

The benefits of pesticide use in agriculture are evident in every agricultural system worldwide (Popp, 2013). High use intensity countries above 10 kg ha^{-1} yr^{-1} include Surinam, Columbia, Chile, Palestinian, Malta, Korea, Japan and China (FAO, 2015a).

Indian economy is based on agriculture and it contributes 18 % to GDP. In ensuring the food security to such a large population the pesticides play an important role in Indian agriculture.

The pesticide use in India was 50.58 thousand tonnes (Anonymous, 2012) India ranks 10th in the world in pesticides consumption as its total consumption amountsto about 500 million tonnes. India is presently the largest manufacturer of basic pesticides among the South Asian and African countries, with an exception of Japan. The Indian pesticides market is the 12^{th} largest in the world (Anonymous, 2012).

In India the improvement in crop production is achieved by pesticides along with fertilizers and high yielding verities. For example, Cotton and rice productivity has increased by a factor of 1.9 and 1.8 times respectively using pesticides. During green revolution the extensive use of pesticides over showed it as traditional method.According to one estimate, every rupee spent inchemical pest control helps saving crop output worth Rs. 3. The average per hectare consumption of pesticides in India had increased from 3.2 gm in 1954-55 to 570 g in 1996 (Bami, 1996). The present use of pesticides in Indiawas 80 g per hectare which is very low as compared to Taiwan (17 g/ha) followed by Japan (16.5 kg/ha) and in the US it is 4.5 kg/ha (Kumarswamy, 2008).

Since green revolution has been started in 1966 the modern agricultural technologies which play vital role are fertilizers, plant protection measures, irrigation and improved seed. In absence of adequate plant protection, the other positively contributing factors to output could be eradicated. Hence the new technology is unfortunately ropes the extensive use of agrochemicals. An Agro-chemical includes such chemicals as insecticides, herbicides, fungicides, and fertilizer, which are used on plants, soil and water to control pest and diseases. In advanced countries the production inputs are matched with protection measures using agrochemicals, results in the increase of more than 50 percent of yield.

Pesticides have substantially contributed for controlling of pests and increasing crop yields.But over the years there is growing concern about indiscriminate use of pesticides in agriculture. The consumption of chemical pesticides in agriculture went up from 2,350 metric tonnes (technical grade) in 1950-51 to 75,033 metric tonnes (MT) in 1990-91, and subsequently declined to 39,773.78 metric tonnes in 2005-06. The recent statistics on consumption of pesticides (technicalin India together they account for around 57% of the total pesticideconsumption. While the wheat and pulses contribute of about 4 %, vegetable 9 % and the other plantation crops 7 % (Ministry of agriculture, 2009). State wise Andhra Pradesh is the highest pesticides consuming state (23%) followed by Punjab & Maharashtra grade) for the year 2005-06 shows that Uttar Pradesh is the leading consumer of pesticides (6672 MT) followed by Punjab (5610 MT), Haryana (4560 MT), West Bengal (4250 MT) and Maharashtra (3198 MT).

In 1955, DDT was the first pesticide imported in Nepal and then BHC. Since 1960s the organophosphorus group of pesticides was introduced. Different pesticides of this group like methyl parathion, Malathion slowly gained their markets replacing the monopoly markets and use of BHC and other organochroine pesticides (Klarman, 1987).

Pakistan economy is dependent on the production of fruits and vegetables. And no doubt, Pakistan is one from those countries who are using pesticides in large amount to increase their production. A large part of fruits and vegetables production in Pakistan being export to other countries. The Brazilian agribusiness also adopted the technological advances in agriculture in which the most important role was played by the use of pesticides to increase the productivity and enabling competitiveness in the international market.

To increase the productivity of vegetable crops, Kuwait has increased its agricultural pesticide use (Jallow, 2017). Most vegetables in Kuwait are produced under protected environments, accounting for more than 90% of the total greenhouse crop production (Kuwait Agricultural Statistics, 2017). The annual consumption of pesticides in Kuwait was about 4.5 kg_ai.ha-1per year in 2007 (Bashour, 2008) and this has increased to 12.8 kg_ai.ha^{-1} per year by 2015 (Mustapha, 2017). A total of76 pesticide active ingredients, including pyrethroids, organophosphates and carbamates, were foundto be in use, and 9% of these belong to the World Health Organization (WHO) toxicity class Ib (highlyhazardous) (Jallow, 2017).

Pesticide Residue in food and food products

Study conducted by (Dikshit and Mishra, 1985) in fruits and vegetables in Gujrat state reveals the carbaryl and endosulfan residue was higher than the tolerance limit of 2.00 and 5.00 ppm respectively.In case of endosulfan @ 0.525 kg a.i./ha, the residues persisted to the level of 2.00 ppm at 65 days (30 days' storage). (Reddy, 2000) monitored the insecticide residues in market samples of grapes. The residues level of acephate, methamidophos, chlorpyriphos, monocrotophos and quinalphos in var. Thompson seedless were (above MRL), 2.6743, 0.1383, 0.8341, 1.3648 and 0.4132 mg kg^{-1}, respectively.

Despite the fact that the consumption of pesticides in India is still very low, about 0.5 kg/ha of pesticides against 6.60 and 12.0 kg/ha in Korea and Japan, respectively, there has been a widespread contamination of food commodities with pesticide residues, basically due to non-judicious use of pesticides. In India, 51% of food commodities are contaminated with pesticide residues and out of these, 20% have pesticides residues above the maximum residue level values on a worldwide basis. It has been observed that their long-term, low-dose exposure are increasingly linked to human health effects such as immune-suppression, hormone disruption, diminished intelligence, reproductive abnormalities, and cancer. In this light, problems of pesticide safety, regulation of pesticide use, use of biotechnology, and bio pesticides, and use of pesticides obtained from natural plant sources such as neem extracts are some of the future strategies for minimizing human exposure to pesticides (Gupta, 2004).

Risk assessment

To assess the risk of a pesticide to human health or the environment EPA considers the toxicity of the pesticide as well as the amount of pesticide to which a person or the environments may be exposed. In assessing exposure, scientists frequently use mathematical models to predict pesticide concentrations in food, water, residential and occupational environments. Some available models are Aquatic models, Terrestrial model, Atmospheric models and Health effect models.

Health Effects Models

In the safety assessments of EU maximum residues levels (MRLs) for pesticides, or proposals for MRLs, the chronic and acute dietary consumer exposure to pesticide residues is estimated by using a calculation model developed by EFSA (PRIMo – Pesticide Residue Intake Model). The model is based on national food consumption figures and unit weights provided by Member States and implements internationally agreed risk assessment methodologies to assess the short-term (acute) and long-term (chronic) exposure of consumers. The calculation model was initially developed by EFSA for the risk assessment of temporary MRLs.

Since that, revised versions of the model for calculating the acute and chronic consumer exposure have been developed, the most recent one being PRIMo revision 3, which should be used for new applications as from 1 February 2018. A detailed description of the tool is made available in a guidance document.

The EFSA model

The calculation model was initially developed by EFSA for the risk assessment of temporary MRLs. A revised version of the model for calculating the acute and chronic consumer exposure (revision 2) with additional features for refined intake calculations is also available. In the safety assessments of EU maximum residues levels (MRLs) for pesticides, or proposals for MRLs, the chronic and acute dietary consumer exposure to pesticide residues is estimated by using a calculation model developed by EFSA (PRIMo – Pesticide Resïdue Intake Model). The model is based on national food consumption figures and unit weights provided by Member States and implements internationally agreed risk assessment methodologies to assess the short-term (acute) and long-term (chronic) exposure of consumers.

To estimate the short and long term dietary exposure to pesticide residue via food in this study the EFSA model is applied for a case study of Chlorpyrifos pesticide concentration (Vindhiya Patel, 2014; Sah, 2018; Pujeri, 2015; Yuwei Yuan, 2014; Anam Munawar, 2013) in food products of different state and country. The results of the model applied are shown in Table 1-5.

The consumer is considered to be adequately protected when estimated dietary intake of pesticide residues does not exceed the acceptable daily intake (ADI) or the acute reference dose (ARfD).

CONCLUSION

Though pesticides provide several indirect benefits to the society by increasing agricultural yield but they are also dangerous from human and environment safety point of view. We can minimize the harmful effects of pesticide by using them in appropriate quantity and only when required and necessary. Water pollution is on the rise due to these pesticides, even at low concentration,these pesticides have serious threat to the environment

Table 1. EFSA model applied for Chlorpyrifos concentration in food products of Chhattisgarh State (Mustafa *et al*., 2017)

	Acute Overview Children				Acute Overview Adults			
	%ARfD	IESTI1	%ARfD	IESTI2	%ARfD	IESTI1	%ARfD	IESTI2
Orange	168.4	0.1684	121.7	0.1217	32.5	.0325	26.4	0.0264
Apple	233.2	0.2332	171.9	0.1719	53.4	0.0534	44.4	0.0444
Egg plant	117.5	0.1175	117.5	0.1175	116.9	0.1169	116.9	0.1169
Spinach	88.1	0.0881	88.1	0.0881	34.9	0.0349	34.9	0.0349
Rice	46.6	0.04	46.6	0.0466	27.8	0.0278	27.8	0.0278

Table 2. EFSA model applied for Chlorpyrifos concentration in food products of Bihar State (Neff *et al*., 2012)

	Acute Overview Children				Acute Overview Adults			
	%ARfD	IESTI1	%ARfD	IESTI2	%ARfD	IESTI1	%ARfD	IESTI2
Cabbager	6.4	0.0064	6.4	0.0064	3.84	0.0038	2.3	0.0023
Cauliflower	3.8	0.0038	3.8	0.0038	1.81	0.0018	0.0018	1.8

Table 3. EFSA model applied for Chlorpyrifos concentration in food products of Karnataka State (Palikhe, 2001)

	Acute Overview Children				Acute Overview Adults			
	%ARfD	IESTI1	%ARfD	IESTI2	%ARfD	IESTI1	%ARfD	IESTI2
Cabbager	bdl	bdl	bdl	bdl	bdl	Bdl	bdl	bdl
Cauliflower	6	0.0060	6	0.0060	2.87	0.0029	2.9	0.0029

Table 4. EFSA model applied for Chlorpyrifos concentration in food products of China [24]

	Acute Overview Children				Acute Overview Adults			
	%ARfD	IESTI1	%ARfD	IESTI2	%ARfD	IESTI1	%ARfD	IESTI2
Carrot	50.1	0.0501	35.8	0.0358	9.4	0.0094	7.5	0.0075
Tomatoes	16.9	0.0169	12.2	0.0122	4.4	0.0044	3.6	0.0036
Egg plant	2.2	0.0022	2.2	0.0022	2.1	0.0021	2.1	0.0021
Cucumber	6.4	0.0064	6.4	0.0064	2.2	0.0022	2.2	0.0022
Cabbager	4.7	0.0047	2.8	0.0028	2.86	0.0029	1.7	0.0017

Table 5. EFSA model applied for Chlorpyrifos concentration in food products of Pakistan [25]

	Acute Overview Children				Acute Overview Adults			
	%ARfD	IESTI1	%ARfD	IESTI2	%ARfD	IESTI1	%ARfD	IESTI2
Pumpkin	3.8	0.0038	3.8	0.0038	5.9	0.0059	5.9	0.0059
Egg Plant	4.2	0.0042	4.2	0.0042	4.2	0.0042	4.2	0.0042
Spinach	8.1	0.0081	8.1	0.0081	34.9	0.0349	34.9	0.0349
Cucumber	8.7	0.0087	8.7	0.0087	2.9	0.0029	2.9	0.0029
Cauliflower	7.5	0.0075	7.5	0.0075	2.59	0.0036	3.6	0.0036

(Agrawal, 2010). Lack of awareness among farmers about type, level of poisoning and safety measuresto be taken against pesticide leads to intentional, incidental and occupational exposure. Awareness should be arranged for farmers to reduce the uses of toxic pesticides (Sharma, 2012).

In future chemical pesticides can be used in combination with natural treatments and remedies which result in more sustainable elimination of pests and insects. This combination not only promises environmental sustainability, but also has diverse applications in controlling of urban pests and invasive species (Gentz, 2010). Pesticides have also posed a serious threat on biological integrity of marine and aquatic ecosystems. It is the need of time to integrate the studies of different disciplines including toxicology, environmental chemistry, population biology, community ecology, and conservation biology and landscape ecology to understand direct and indirect effects of pesticides on the environment (Macneale, 2010).

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