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Pesticides contamination in potatoes and associated health risk to population with respect detection limits

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Abstract
The objective of the review is to document, assess and analyze the results of the previously reported data on pesticides application and their residues in potato from different countries. This research subject covers a complex relationship of the pesticides application in potato field, residues concentration in potato, and human health risk. Hazard risk index (HRI) were calculated for Imidaclorpid, Metalaxyl Chlorpyrifos, Previcur-N 72.2%, Proplant 72.2%, Prothiofos, 3,5,6 tricholoro-2-pyridinol, Profenofos, Monolinuron, Mancozeb, Manzate D, Manzate 200 and Manzate pesticides in potato. The findings of the previous studies indicated that only porthiofos contaminated potato crosses the HRI unity. The results also highlights the data on pesticide application and residues in potato cultivation is limited which should be overcome by further extending studies from different countries in the world. In order to establish the condition of good potato for human consumption as potato make significant part of human diet, it is essential to monitor pesticides residue in potato by the country authorities and implement guidelines based on permissible limits.

Keywords: pesticides, potato, residues, contamination and hazard risk index (HRI)

Introduction
Potato ranks third in importance as a single food crop worldwide and fourth most important food crop in India after rice, wheat and maize, and from the beginning it played a key role in food security. According to Indian horticulture database (2013) [1], an average production of potato was 22.8 metric tons per hectare during 2012-13 in India and became the second largest producer of potato worldwide [Scott and Suarez (2011) [2]. Currently, a high diversity of potato varieties still plays a key role in the diet and culture of the Indian populations and about a billion people currently eating potato. Cultivation of crop is more than one hundred countries from different continents because of their extraordinary adapting capacity to different climatic and soil conditions. The flexibility and adaptability of the potato have been recognized in the development policies of some countries and cultivated as a cash crop in several countries, representing an income generation opportunity for farmers.

Potato is one of the most pesticides demanding agricultural crops and health risks related to pesticides use in potato production are high, especially in developing countries. Pesticides contain toxic substances that can cause health implication upon human (Hellweg and Geisler, 2003) [3]. The harmful effects of the pesticides are now established worldwide. The monitoring of pesticides residues in the potato is necessary act due to the potential risk they pose to community health. The pesticides residues left in potato after use get into the human food chain. Intake of pesticide residues through food and water has been linked to birth defects, toxicity to fetus, cancers, genetic defects, blood disorders, neurotoxicity and endocrine disruption.

Most of the studies have been conducted measuring the residues of pesticides in food commodities all over the world as revived by Fantke and Juraske (2013) [4]. Also, in India, numerous pesticides residues studies exist that have been conducted on food commodities including fruits and vegetables. However, to the best of our knowledge, there is no comprehensive review on pesticides residue on potato which covers all existing data of pesticides application and residues in potato samples collected from the agricultural field. The present review documents the results of previously reported data and evaluate the residue levels of different pesticides in potato and associated health risk shown in table 1, collected from different countries in the world.

Use of Pesticides
The use of pesticides helped in controlling pests in other hand invited new types of crisis including pesticide resistance in insects, damage to bio-control agents, loss of biodiversity, toxic residues in the vegetables and fruits and pollution of soil, air and water. In the twentieth century, the global food demand increased with the increase in world population. This led to the agricultural strengthening (Merrington *et al*. 2004) [5] beside use of agricultural chemicals including pesticides. The pattern of pesticide use differs significantly between the countries fig 1. Around the world pesticide consumption is about two million tons per year, of which 24% is consumed in the USA alone, 45% in Europe and 31% in the rest of the

world (Abhilash and Singh 2009) [10].

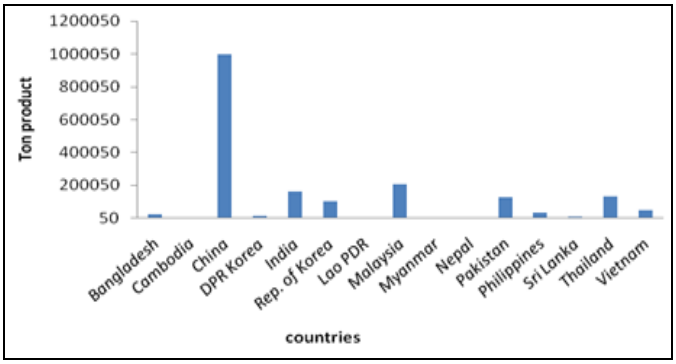

Fig 1: Annual pesticides consumption in different countries (Abhilash and Singh 2009) [10]

According to Indian institute of vegetable research, most pesticides used in India were insecticides (60 %), followed by fungicides (19 %), herbicides (16 %), biopesticides (3 %), and other (3 %), out of which only 13% used in vegetables, of which insecticides account for two-thirds of total pesticides used in vegetables. As a consequence high pesticides residues are found in fruits and vegetables as compared to other food commodity. Different types of pesticides are used on different fruit and vegetable in world. In Punjab (88.3%) and Sindh (8.2%) maximum use of pesticides followed by North-West Frontier Province (NWFP) (2.8%) and Balochistan (0.76%), out of which 11.9% pesticides are used on fruits and vegetables crops (Khan *et al*., 2010) [6].

Concentration of Pesticides

Pesticides are extremely valuable compounds that increases crop productivity, at the same time as, these may lead to some draw backs in form of pesticide residues, which remain on potatoes. Pesticides residue concentration in potato depends on number of applications in agricultural field which can lead to increase consumption of pesticides. The present study documents the outcomes of previously reported data and evaluate the residual levels of different pesticides in potatoes collected from different countries. López-Pérez *et al*. (2006) [7] studied on potato by using insecticides, fungicides, nematicides and herbicide, pointed out only one fungicide was present in the tuber, and concentration was below MRL. According to few early studies conducted by Abdel-Gawad *et al*., (2008) [8] the concentrations of Prothiofos was found in higher than MRL value of this pesticides for potato. Abd-Alrahman & Almaz, (2012) [9] studies on Previcur-N 72.2% and Proplant 72.2% in potato field and observed that if crop was harvested within 5 day after last application the residual concentration excided the MRL value. A study carried out by Juraske *et al*., (2011) [11] reported the occurrence and residue levels of frequently used pesticides, like Chlorothalonil, Chlorpyrifos, Cymoxani, Glyphosate, Mancozeb, Metamidophos and Paraquat in potato and samples being collected from the field. The study showed that in all the studied samples, only chlorpyrifos pesticides residues was found however, none of the samples exceeded the permissible limits of pesticide. Randhawa *et al*., (2007) [12] and López-Pérez *et al*. (2006) [7] were showing similar trends of results from potato cultivation fields. A pesticide residue studies are most complex problem, variation within species of plants and within plants of same species to, even great variability is reported when analysis of single fruit differs from the analysis performed on an aliquot of the same lot set up by more fruits (Fantke and Juraske 2013) [4].

Pesticides residues in potato samples were compared with the maximum residue limits (MRLs) set by the WHO for every pesticide in respective items. The results showed that most of the samples did not contain any residues of the selected pesticides. Thus, the authors concluded that the analyzed potato samples did not pose a serious threat to the health of the consumers. The lack of awareness of farmers about application dose, methods of application and appropriate interval between harvesting and pesticide treatment, as well as carelessness of proper guidance about pesticide application may lead to high pesticide residue levels on potatoes. Some studies blamed the poor level of execution of rules and regulations regarding the use of pesticides by various national and regional legislative authorities. On the other hand, the presence of existing stockpiles of obsolete pesticides, and the highly persistent nature of these pesticides resulted in severe contamination of different environmental media and posed many health threats due to long term accumulation in the food chain.

Health risk Assessment

The human health risk assessment from the view of food safety is to ensure that ADI values were determined by the pesticides ingested from a variety of sources (i.e., vegetables and fruits, milk and their derivates). Monitoring of pesticide residues is an important tool for ensuring agreement with pesticide regulations and providing a good agricultural practice. The health risk assessment process considered the maximum exposure to pesticide residues to ensure that the ADI of the pesticides are not exceeded. This is helpful for assessing exposure to pesticides through the food supply and for understanding the level of health risk.

In this review, the authors compiled the available data on pesticide residues in potato. On the basis of previously conducted studies in different countries in the world, hazard risk index (HRI) is used for human health risk assessment given in table 1. For HRI assessment, the estimated average daily intake (EADI) (mg/kg/day) and acceptable daily intake (ADI) values (mg/kg/day) were taken and calculated by following international guidelines (Darko and Akoto, 2008) [14], as shown in Eqs.1 and 2.

$$\text{EADI} = \text{Mean concentration (mg/kg)} \times \text{Consumption rate (kg/day)} \quad (1)$$

Reference values for the food consumption rate for calculation of ADI is taken from literature as 42 kg/person/year for potato, while 60 kg is considered as an average adult weight (Juraske *et al*., 2011) [11]. HRI was calculated by dividing EADI by ADI as shown in Eq. 2 and if the calculated value of

HRI is greater than 1 then it is indicating an unacceptable risk to human health (Darko and Akoto 2008) [14].

$$HRI = EADI / ADI \quad (2)$$

In this manuscript an effort was made to estimate the concentration of pesticides applied in field and pesticides residue in potatoes after harvests from the worldwide and the obtained data was used to evaluate human risk to these pesticides. Table 1 summarizes health risk assessment of pesticide residues in potato on the basis of ADI of some selective studies from different countries. From those selected studies calculated values of health risk indices of Imidaclorpid, Metalaxyl Chlorpyrifos, Previcur-N 72.2%, Proplant 72.2%, Prothiofos, 3, 5, 6tricholoro-2-pyridinol, Profenofos, Monolinuron, Mancozeb, Manzate D, Manzate 200 and Manzate pesticides only prothiofos crossed the unity in potato shown in table 1. Thus, the health risk is caused by only this pesticide residue, while the rest of the studied pesticides cause no harm to human health. Considering the results of this review, it must be considered that values of daily dietary exposure were estimated for only maximum harvest time and not including the cooked potatoes and mid harvest time for potato crop. At the same time, while estimating health risk, food processing factors like washing, peeling and cooking were not taken into consideration. However, these high HRI values of pesticide residues in potatoes are a serious health concern and there is a need of continuous monitoring and strict regulations should be implemented by the Government agencies regarding safe doses of pesticides application and residues in potatoes.

Table 1: Risk assessment of pesticides residues in potato on the bases of ADI (Average daily intake)

Study area	Detected pesticides	ADI (mg/kg/day)[a]	EADI (mg/kg/day)	HRI	Health risk assessment	Ref.
Institute area	Imidacloprid	0.06	0.0006	0.01187	No	Chauhan *et al*., 2013 [15]
Plot B	Metalaxyl 10%	0.03	0.00003	0.001	No	López-Pérez *et al*., 2006 [7]
Plot C	Metalaxyl 10%	0.03	0.000032	0.00106	No	
Plot D	Metalaxyl 10%	0.03	0.000033	0.0011	No	
Institute area	Chlorpyrifos	0.01	0.000024	0.0024	No	Juraske *et al*., 2011 [11]
Institute area (both pesticides are applied in same field)	Previcur-N 72.2%	0.1	0.000038	0.00038	No	Abd-Alrahman & Almaz, 2012 [9]
	Proplant 72.2%	0.1	0.00019	00019	No	
Institute area	Prothiofos	0.0001	0.0012	12.27	Yes	Abdel-Gawad *et al*., 2008 [8]
Institute area (both pesticides are applied in same field	Chlorpyrifos	0.01	0.00026	0.026	No	Randhawa *et al*., 2007 [12]
	3,5,6 tricholoro-2-pyridinol	0.03	0.000017	0.00057	No	
Institute area	Profenofos	0.0001	0.022	0.733	No	Habiba *et al*., 1992 [16]
Plot 1	Mancozeb	0.006	0.00015	0.0255	No	Newsome, 1979 [16]
Plot 2	Mancozeb	0.006	0.00015	0.0255	No	

Note: ADI reference values were taken from the AG (2016)

Table 1 contains the average daily intake values of the pesticides residues in potato and their corresponding hazard indices in the samples. Hazard index for Prothiofos is 12.27 in potatoes are more than one. Thus, life time consumption of potato could pose some health risks due to the level of pesticides residues present in them. No health risks are found with consumption of potatoes as the hazard index for all the residues in potatoes are less than one in this study. This document has provided important information of pesticides residues contamination on potatoes growing different countries in the world.

Effects on human health

Constantly using of pesticides in agricultural field for production of vegetables, fruits and grains has been identified as the major source of various harmful effects on humans, animals and ecosystems, some authors reported that the most important exposure pathway is consumption of directly treated crops (Osman *et al*., 2011, Juraske *et al*., 2009 and Fantke *et al*., 2011) [19, 21, 4]. This study is important because of a concern that these pesticides have an effect on humans and environment to obtain an insight on site specific conditions on which the chemical fates and toxicological behavior of pesticides depend. The selection of pesticides in fruits and vegetables depending on multiple criteria and subsequent risk assessment is a complex task. Although, different prioritization approaches are available for identifying pesticides of concern in potato (Juraske *et al*., 2011) [11]. Some study reported that the pesticides residue is above than the maximum residual limits (MRLs), the concentration of Carbofuran 0.01-0.39 mg/kg and Chlorpyrifos 0.05-0.96 mg/kg were found in vegetables (Latif *et al*., 2011) [18].

Conclusion

The consumption of pesticide is increasing day by day due to the high increase in the demand for potato as make a significant part of diet, which leads to an increasing need for crop protection. These higher applications of pesticides resulted in higher contamination of potatoes. The review highlights that health risk evaluated on the available data from previous studies from different countries in the world, which might not have touched upon the actual issue. It is therefore recommended that detailed surveys and studies should be formulated with help of experts from research organizations to build a baseline data which may be helpful in pesticides application and contamination in potato. These pesticides cause harmful effects on the food commodities which ultimately causes a damaging impact on the health of human. This problem is not limited to India, and it is a very important issue on a worldwide. In this review, estimated a human risk

assessment by using hazard risk indices of available pesticides concentration in potato from different countries and some pesticides crossed the HRI value shown in table 1 and it is serious health concern for human. Thus, it is essential to come up having an authorization of the pesticide application and residue monitoring in potato to educate the stakeholders about the fate of the pesticides. It will not only protect the human health but will provide a cost effective practices for potato cultivation.

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