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Monitoring of heavy metal residues in cauliflower and their respective health hazards

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Abstract

The safety of food plays important role in the growing vicinity of worldwide because it's direct attitude on human health. Safe food production is vital feature of food safety and quality as well as human. To study the level of heavy metal residues in cauliflower grown in peri-urban area of district Faisalabad and to compare the level of heavy metal residues with their respective maximum residual limits (MRLs). Ten farmers growing cauliflower in the peri-urban environment of district Faisalabad were randomly selected. Cauliflower samples grown in the peri-urban farming systems of district Faisalabad were collected at optimum maturity stage. Thirty samples of each vegetable were procured from the selected farmers. Samples were kept in polyethylene air tight bags then transported to the laboratory of National Institute of Food Science and Technology, University of Agriculture, Faisalabad for immediate processing. The heavy metals were determined by Atomic Absorption Spectrophotometer. The results pertaining heavy metals residues in different cauliflower samples collected from District Faisalabad showed variable results. The heavy metal residues varied as nickel 0.013 to 0.523 mg kg^{-1}, lead 0.012 to 1.442 mg kg^{-1}, zinc 0.236 to 1.734 mg kg^{-1}, copper 0.121 to 0.548 mg kg^{-1}, arsenic 0.016 to 0.79 mg $kg^{-1}$and mercury 0.003 to 0.043 mg kg^{-1}. The cauliflower samples are contaminated with number of heavy metals because it is grown with sewerage water that should not disposed after suitable treatment and wastewater is the single largest contributor of heavy metals accumulation in cauliflower.

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Introduction

The vegetables are edible portions of herbaceous plants and are considered as natural caches of essential nutrients. Vegetables are the fundamental food and extremely supportive for the protection of health and prevention of various chronic diseases, repair the body organ, maintain the alkaline reserve of the body and are rich source of carbohydrates, vitamins and minerals (Marwat *et al.,* 2009). The vegetables like cauliflower and spinach are most commonly consumed by people all over the Pakistan. Cauliflower has high nutritional values, low fat content and contains high folic acid, dietary fiber, vitamin C and water. A lot of phytochemicals, riboflavin, ascorbic acid, carotene, folic acid and minerals like calcium, phosphorous and iron that is beneficial to human being are also present in cauliflower.

The chemical configuration of vegetables shows high sugars content, water content, starch, protein, fat and energy in calories (Munteanu *et al.,* 2011). The contamination of heavy metals mostly occurs due the application of fertilizers, waste water irrigation, use of metal-based pesticides, industrial emissions and transportation on crops (Agrawal and Marshall, 2003). The contamination of soil is becoming environmental problem in Pakistan due to increasing heavy metals (Bhutto *et al.,* 2009). The wastewater irrigation is the major contributor of heavy metal contents to the soil and vegetables ultimately they becoming a very serious issue in Pakistan because these effluents are heavily loaded with harmful metals and metallic compounds (Singh *et al.,* 2004, Mapanda *et al.,* 2005, Sinha *et al.,* 2005; Sharma *et al.,* 2006).

When the concentration of heavy metals increase above the maximum residues limits then they cause various types of diseases; arsenic causes pigmentation, irritation of skin, polyneuritis and black foot disease; cadmium causes congenital abnormalities, dried scaly skin, loss of sense of smell, hair loss and pregnancy toxemia; mercury causes neurological signs; copper causes liver, kidney and brain damage; lead toxicity may results in bone disease, kidney damage, cardiovascular and nervous disorder; zinc can result in abnormal growth and reproduction (Divrikli *et al.,* 2006).

The aim of this study is to determine the residues of heavy metal in cauliflower to explore the maximum residues limits further discuss their injurious human health hazards.

Materials and methods

Selection of farmers

Ten farmers growing cauliflower in the peri-urban environment of district Faisalabad were randomly selected.

Collection of samples

Cauliflower samples grown in the peri-urban farming systems of district Faisalabad were collected at optimum maturity stage. Thirty samples of each vegetable were procured from the selected farmers. Samples were kept in polyethylene air tight bags then transported to the laboratory of National Institute of Food Science and Technology, University of Agriculture, Faisalabad for immediate processing. The heavy metals were determined by Atomic Absorption Spectrophotometer.

Sample preparation for heavy metals

Size reduction

Collected samples of cauliflower and spinach were reduced to appropriate size by using knife to facilitate the further processing.

Sample drying

The vegetable samples were kept in hot air oven at 70 to 80 °C till complete dryness.

Sample digestion

The dried vegetable sample (2g) were taken into a Pyrex beaker, 10ml of concentrated HNO_3 were added to it and kept overnight without heating. It was then heated on a hotplate near to dryness, the sample was cooled and 5ml $HClO_4$ were added and heated again. The digestion was complete when the samples become colorless and then were filtered into a clean volumetric flask and diluted to 50ml with double de-ionized water (Nwajei, 2009).

Preparation of standards

The standard solutions of all the metals (Ni, Pb, Zn, Cu, As and Hg) were prepared from the stock standard solutions containing 1000 ppm in distilled water. Calibration and measurement of elements were carried out through atomic absorption spectrophotometer.

Determination of trace metals

The residue of heavy metals Ni, Pb, Zn, Cu, As and Hg were determined by using Varian GTA 120 AA 240 Graphite Atomic Absorption Spectro-photometer (AOAC, 2006).

Results and discussion

The analysis of variance for residues of heavy metal in cauliflower samples collected from Faisalabad district irrigated with sewage water have been shown in Table 1. The results regarding mean values of all heavy metals detected in cauliflower samples indicated in Table 2.

Table 1. Analysis of variance for heavy metal residues in cauliflower collected from Faisalabad.

	Mean squares					
	Nickel	Lead	Zinc	Copper	Arsenic	Mercury
Source of variation						
Farmer (9)#	0.0836200**	0.8747500**	0.5026600**	0.0496200**	0.0010500**	0.0007004**
Error (29)	0.0000041	0.0000031	0.0000027	0.0000029	0.0000034	0.0000028

values within the braces are degrees of freedom;

** = Highly significant (P<0.01).

Table 2. Mean values for heavy metal residues in cauliflower collected from Faisalabad (mg/kg^{-1}).

Farmer	Nickel	Lead	Zinc	Copper	Arsenic	Mercury
FC-1	0.015 I	1.313 b	0.679 d	0.323 c	0.032 e	0.005 def
FC-2	0.021 h	0.023 g	0.521 g	0.121 j	0.023 f	0.003 f
FC-3	0.523 a	0.123 e	0.236 j	0.233 e	0.016 g	0.004 ef
FC-4	0.323 b	0.433 c	0.514 h	0.312 d	0.033 e	0.007 d
FC-5	0.312 c	0.212 d	0.711 c	0.215 f	0.055 b	0.034 b
FC-6	0.214 e	0.021 g	0.424 i	0.126 i	0.079 a	0.004 def
FC-7	0.128 f	0.114 f	0.633 e	0.193 g	0.024 f	0.033 b
FC-8	0.092 g	0.123 e	1.734 a	0.548 a	0.053 b	0.013 c
FC-9	0.243 d	0.012 h	0.534 f	0.327 b	0.045 c	0.043 a
FC-10	0.013 i	1.442 a	0.923 b	0.157 h	0.037 d	0.006 de

Means sharing similar letter in a column are statistically non-significant (P>0.05).

FC= Faisalabad cauliflower (1-10 = shows farmers from cauliflower samples were collected).

The results pertaining heavy metals residues in different cauliflower samples collected from District Faisalabad showed variable results. The heavy metal residues varied as nickel 0.013 to 0.523 mg kg^{-1}, lead 0.012 to 1.442 mg kg^{-1}, zinc 0.236 to 1.734 mg kg^{-1}, copper 0.121 to 0.548 mg kg^{-1}, arsenic 0.016 to 0.79 mg kg^{-1}and mercury 0.003 to 0.043 mg kg^{-1}. No sample of nickel exceeded their MRLs of 5 mg kg^{-1} indicating that no cauliflower samples had residue level above MRLs. On the other hand, all the samples were found to have heavy metal residues which fall below the MRLs.

It is evident that among cauliflower samples, three samples were found with lead exceeding their MRLs i.e 0.3 mg kg^{-1}indicating that 30% cauliflower samples had residue level above MRLs proposed by FAO. However seven cauliflower samples contained lead residues which fall below the (MRLs). The results further showed that out of ten cauliflower samples, no sample of zinc possessed residue limit exceeding their MRLs of 9.4 mg kg^{-1}. In all cauliflower samples, copper residues could be detected which were below the MRLs.

The result further showed that out of ten samples of cauliflower, no sample possessed residue of arsenic exceeding their MRLs of 0.1 mg kg^{-1}. Out of ten cauliflower samples, three samples were found with mercury exceeding their MRLs of 0.03 mg kg^{-1}indicating that 30% cauliflower tested samples had residue level above MRLs.

The irrigation with sewage water is recognized to contribute potentially the heavy metal contents to the soils and ultimately in vegetables (Mapanda *et al.,* 2005). The serious problem occurs in streams where pollutants are leached from contaminated soil. Although if the plants are die and decays then heavy metals taken in to plants are redistributed ultimately soil is enriched with the pollutants. The process of absorption and deposition of heavy metals by plants may follow two different routes, including roots and leaf area (Sawidis *et al.,* 2001). There are different factors that plays important role for uptake of heavy metals from soil such as soluble contents of heavy metals, pH of soil, Growth stages of plant, types of plants, fertilizers and soil (Sharma *et al.,* 2006; Ismail *et al.,* 2005). The Plant species have a variety of tendency to accumulate and remove heavy metals some plant species may file specific heavy metals that trigger a serious human health hazard when plants based foods are consumed (Wenzel and Jackwer, 1999). The disposal of sewage and industrial waste is a serious problem and is discharged to the farmland where it is used for crops including vegetable cultivation. This waste sewage are considered an important source of organic matter and other nutrients, but they also uplift the level of heavy metals such as lead, cadmium, Copper, Nickel, Zinc and Arsenic in soil (Singh *et al.,* 2004). As consequences it leads to contamination of the food chain and vegetables have the ability to absorb heavy metals from the soil, polluted air and water. The most important contributing factor to the heavy absorption by the way irrigated with wastewater contaminated metals. Heavy metals are not readily biodegradable and as a result may be deposited in the vital organs of man, this type of condition causes varying degrees of the disease on the basis of chronic and acute exposures (Demirezen and Ahmet, 2006).

In Pakistan, agriculture, automobile and industry are the main sources of heavy metal contamination and naturally, they are present in the earth's crust and in sediments resulting causes marine contamination. Many developing countries like Pakistan has still unplanned infrastructure resulting increased contamination in biosphere through poor management of waste water. Furthermore, soil contamination occurs due to discharge from textile industries and tanneries. The heavy metals toxicity poses a dangerous threat to the plants, animal, microorganisms and human health. The toxicity in plants exposed to heavy metals residues results injury in terms of chlorosis along with deadly effects in the form of blockage of photosynthesis, growth inhibition, browning of root tips and finally death. The heavy metals present in the soil highly affected the population of microbes. The higher amount of heavy metal residues causes immune systems suppression, neurological damage and fetal abnormalities in human and mammals. The toxicity of heavy metals to livestock due to food chain causes serious economic and health issues. The present study provides the information regarding contamination and toxicity of heavy metals pollution throughout the world especially in Pakistan.

The use of polluted/sewage water resulted to enhance the transformation of nickel, lead, zinc, copper, arsenic and mercury to the edible tissues of vegetables. The lead is most ubiquitous toxic metal which enters the food chain mainly through aerial deposition and absorption by external parts as well as through soil (Tehvonen and Kumpulainen 1991). The content of lead exceeding the MRL can cause health problems like brain and liver damage, tumor formation, enzyme inhibition to the human as has been reported by Gruenwedel (1990). The zinc is most important and a vital trace component for higher plants and animals. It plays vital role to energy metabolism, transcription and translation due to variety of enzyme systems. In some soils the higher level of zinc is present due to human activities and it is potentially dangerous and excessive contents in soil result in phytotoxicity and eventual entry to the food chain (Anglin-Brown *et al.,* 1995).

The element copper is released into the environment mainly by plants wastewater treatment, mining, welding, solid waste disposal, the electroplating process, plumbing, electrical wiring supplies and materials agricultural processes. These factors may contribute to improve the copper in vegetables. The arsenic is most toxic metal, which enters the food chain mainly through herbicide, insecticides contaminated foods and water. The mercury is toxic in its elemental, organic and inorganic form and that causes neurological signs and symptoms.

Conclusions and suggestions

The cauliflower samples are contaminated with number of heavy metals because it is grown with sewerage water that should not disposed after suitable treatment and wastewater is the single largest contributor of heavy metals accumulation in cauliflower.

For this purpose law should be passed by the government obliging the big industries to establish their own waste water treatment plants while small industries should be grouped to cluster to established common waste water treatment plants and provide awareness to the consumers through social media about the health hazards of heavy metal residues.

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