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Assessment of Some Heavy Metals Contamination in Some Vegetable and Canned Foods: A Review

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Abstract

Heavy metal depositions are associated with a wide range of sources such as small-scale industries including (battery production, metal products, metal smelting and cable coating industries), vehicular emissions, resuspended road dust and diesel generator sets. Such problem is getting more serious all over the world especially in developing countries. Heavy metals in general are not biodegradable, have long biological half- life and have the potential for accumulation in different body organs leading to unwanted side effects.

Vegetables are vital to human diet as they contain essential components needed by the human body such as carbohydrates, proteins, vitamins, minerals and also trace elements. Consumption of vegetables is one of the pathways by which heavy metals enter the food chain. In order to eliminate the surface pollution from vegetable thoroughly effective washing must be done with clean water. It is clear from this study that even motor vehicle emissions can be a source of heavy metal contamination in vegetables at road side market. Vegetable farms must be irrigated with safe water, avoiding industrial effluents and sewage disposals.

Keywords: *heavy metals, vegetable and canned foods*

1. Introduction

Food safety is a major public concern worldwide. The increasing demands for food and food safety have drawn the attention of researchers to the risks associated with consumption of contaminated foodstuffs. During the last decades, it was associated with consumption of food stuffs contaminated by pesticides, heavy metals and/or toxins. Heavy metals are among the major contaminants of food and may consider as important problem to our environment. Such problem is getting more serious all over the world especially in developing countries. Heavy metals in general are not biodegradable, have long biological half- live and have the potential for accumulation in different body organs leading to unwanted side effects [1]. Heavy metals contamination may occur due to irrigation with contaminated water, the addition of fertilizers and metal – based pesticides, industrial emissions, transportation, harvesting process, storage and/or marketing. The excessive content of these metals in food is associated with etiology of a number of diseases, especially with cardiovascular, kidney nervous, as well as bone diseases. In addition, they are also implicated in causing carcinogenesis, mutagenesis and retrogensis [2].

Canned foods are valuable commodity worldwide. Many vegetables were found to lose some of their vitamins when harvested. Nearly half the vitamins may be lost within a few days unless the fresh product is cooled or preserved, so canning can be a safe and economical way to preserve the food quality although additional losses of sensitive vitamins in food might destroy during heating process in manufacturing [3].

Toxicological and environmental studies have prompted interest in the determination of toxic elements in food. The ingestion of food is an obvious means of exposure to metal, not only because many metals are natural component of stuffs but also because of environmental contamination and contamination during processing [4]. Tuna fish was recognized as predator able to concentrate large amount of heavy metals. Heavy metals contaminated the canned foods due to the fact that some of the foods such as tuna and tomato paste salsa are canned in metal containers and sealed with metal [5].

1.1 Importance of vegetables

Vegetables constitute essential components of the diet, by contributing iron, calcium and other nutrients which are usually in short supply. Vegetables are vital to human diet as they contain essential components needed by the human body such as carbohydrates, proteins, vitamins, minerals and also trace elements. In recent years (2008) their consumption is increasing gradually, particularly among the urban community. This is due to increasing awareness on foods value of vegetable, as result of exposure to other cultures and acquiring proper education. However, they contain both essential and toxic elements over a wide range of concentrations [6].

Human beings are encouraged to consume more vegetables and fruits, which are a good source of vitamins, minerals, fibers and also beneficial to their health. However, these plants contain both essential and toxic metals over a wide range of concentrations. It is well known that plants take up metals by absorbing them from contaminated soils as well as from deposits on parts of the plants exposed to the air from polluted environments. The publicity regarding the high level of heavy metals in the environment has created a certain apprehension and fear in the public as to the presence of heavy metal residues in their daily food. The public is confused and alarmed about their food safety [1].

A primary concern in urban agriculture is the transfer of trace metals from vegetables through the food chain to humans. For example it has been estimated that this route contributes up to 70% of the dietary intake of Cd. Vegetables may accumulate trace metals from contaminated soil and are also exposed to surface deposition onto their shoots in polluted atmospheric environments. However, little information is available regarding human exposure to contaminants via urban agriculture in developing cities. In many cities in the developing world, there is inadequate or non-existent waste collection, rapidly increasing traffic and largely unchecked industrial contamination. Thus, urban agriculture faces major problems in balancing demands associated with increasing populations against potential hazards arising from the use of contaminated urban sites for consumption of vegetables is one of the pathways by which heavy metals enter the food chain. Excessive accumulation of dietary heavy metals such as Cd, Cu, Ni, As, Pb and Cr can lead to serious health problems. Heavy metals persist in the environment, are non-biodegradable and have the potential to accumulate in different body organs [7].

1.2 Canned food;

Canned foods are becoming valuable commodities worldwide. Food may be canned in glass jar or metal containers and required special sealing equipments. Canning is the process of sterilizing and sealing foods in airtight containers to preserve them. To retain nutrients and optimum quality, preserve fruits and vegetables when at their peak of freshness and clean the food thoroughly before processing. Salt and/or sugar may be added to canned fruits and vegetables but these ingredients are not essential for a safe product. Regular monitoring is needed which has sensitive and selective multi-element capabilities of toxic and essential trace elements in canned food products [8].

1.3 Heavy metals

The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous even at low concentration. Heavy metals are potential environmental contaminants with the capability of causing human health problems if present to excess in the food we eat. They are given special attention throughout the world due to their toxic effects even at very low concentrations. Several cases of human disease, disorders, malfunction and malformation of organs due to metal toxicity have been reported. Legumes, cereals and cereal products are essential foodstuffs for human diet. Many studies pointed out that legumes and cereals contaminated with different levels of heavy metals [9].

Heavy metals are natural constituents of the Earth's crust. Human activities have drastically altered the balance and biochemical and geochemical cycles of some heavy metals. Therefore, the concentration of heavy metals in soils has been an issue of great interest in the past few years not only to ecologists, biologists and farmers but also environmentalists. An assessment of the environmental risk due to soil pollution is of particular importance for agricultural and non-agricultural areas, because heavy metals, which are potentially harmful to human health, persist in soils for a very long time. In addition, according to soil parameters they may enter the food chain in significantly elevated amounts [10].

The term heavy metals usually applied to elements such as cadmium, copper, nickel, mercury and lead which are commonly associated with pollution and toxicity problems. An alternative name for this group of elements is trace elements but it is not widely used. Heavy metals are among the major contaminants of food supply and may be considered the most important problem of pollution. Heavy metals may enter the human body through inhalation of dust, consumption of contaminated drinking water, direct ingesting of soil and consumption of food plants grown in metal – contaminated soil [11].

1.4 Sources of heavy metals contamination in vegetables

Heavy metal depositions are associated with a wide range of sources such as small-scale industries including (battery production, metal products, metal smelting and cable coating industries), vehicular emissions, resuspended road dust and diesel generator sets. These can be important contributors to the contamination found in vegetables. In general, coal combustion is an important source of contamination [12].

In addition to that sources of heavy metals in field locations in urban area include irrigation water contaminated by sewage and industrial effluent leading to contaminated soils and vegetables. Other sources can include unsafe or excess application of pesticides, fungicides, fertilizers and sewage sludge. Heavy metals may be present as a deposit on the surface of the vegetables, or may be taken up by the crop roots and incorporated into the plant tissue. In either case the original source of the pollution may be from water borne sources such as industrial effluent or from industrial or vehicular air pollution. This distinction is very important, because metal deposited on the surface of the crop can often be washed off by consumer prior to consumption. Several studies have indicated that vegetables, particularly leaf vegetables, grown in heavy metal contaminated soil have higher than those grown in uncontaminated soil. A major pathway soil contaminated is through atmospheric deposition of heavy metals from the point source such as smelting and industrial activities [13].

1.5 Sources of heavy metal contamination in canned foods

The ingestion of food is an obvious means of exposure to metals, not only because many metals are natural components of foodstuffs but also because of environmental and processing contamination. Solder used in the manufacture of cans is a recognized source of contamination of food by lead during canning. The presence of heavy metals in environment has been a matter of concern since their toxicity has been clearly documented. Extensive survey have been carried out, in a number of countries to evaluate the presence of heavy metals in aquatic biota, including fish, which can often be considered as indicators of marine pollution. The toxic nature of certain metals and the major contribution made to the total body burden of these metals by food consumption are well documented. Canned tuna fish are frequently and largely eaten, so their toxic metal content should be of some concern to human health [8].

2. Toxicity of heavy metals

Heavy metals may exist either as a deposit on the surface of vegetables, or may be taken up by the crop roots and incorporated into the edible part of plant tissues. Heavy metals are the major contaminates of food supply and may be considered the most important problems to our environment. Heavy metals deposited on the surface can often be eliminated simply by washing prior to consumption, whereas bio-accumulated metals are difficult to remove [14].

Table 1. FAO/WHO guide line values for maximum limit of heavy metals in vegetables [15].

Heavy metals	Maximum concentration level (mg/kg)
Pb	0.3
Cd	0.2
Ni	67.90
Cu	73.3

2.1 Lead

Lead is a soft, dense, and ductile metal. It is a natural environmental contaminant, but its ubiquitous occurrence results, to a great extent, from anthropogenic activities including mining and smelting, soldering, battery manufacturing, ammunition, metal water pipes, and particularly the use in the past of lead in paint and petrol. In the 1970s, the evidence of lead-associated adverse effects led to the implementation of control measures, in both Europe and the U.S. which significantly decreased the exposure levels of the general population. In time, leaded paints, leaded petrol and lead solder in food cans and pipes were strictly regulated or banned [16].

2.1.1 Environmental exposure

Human exposure to lead can occur via food, water, soil, dust and air. Lead exists both in organic and inorganic forms. In the environment, inorganic lead predominates over organic lead. Exposure to the latter is generally limited to occupational settings. Organic and inorganic lead differs in terms of both toxic kinetics and toxic dynamics. Organo-lead compounds, such as tri-alkyl-lead and tetra alkyl-lead compounds, are more toxic than inorganic forms of lead. To some extent, organic lead compounds are metabolized to inorganic lead both in humans and in animals. Lead can be accumulated in the body, primarily in the skeleton. From the skeleton, it is released gradually back into the blood stream, particularly during physiological or pathological periods of bone demineralization such as pregnancy, lactation and osteoporosis, even if lead exposure has already ceased. Lead can be transferred from the mother to the fetus/infant in utters and through breast milk. Lead affects virtually every system in the body, including the blood, the cardiovascular, renal, endocrine, gastrointestinal, immune and reproductive systems [16].

With the development of industry and traffic project, the domestic and industrial fallout of lead (II) contaminated air and water and various wastes from industry and mining enterprise were dispersed into the farmland. Lead (II) enter through food chain and can be accumulated in the body through plants and food. Owing to its great harm to the organs, lead (II) is one of the most toxic elements to human health. Latent severe damage of lead (II) has cause great concern regarding public health. Hence it is especially significant to determine trace lead (II) in food samples [17].

Lead is another widely spread heavy metal with long biological half-life. The main sources of lead exposure are industrial and automobile emissions, water from lead pipes, paint, lead soldered cans and ceramics. Food is a major source of lead exposure in the general population. Lead is absorbed into blood plasma from which it enters the blood cells. About 99% of lead in blood is present in erythrocytes and 90% of the total body burden of lead is found in the skeleton. Lead is excreted mainly through urine and faces.

Environmental lead exposure is particularly toxic to children and may cause adverse effects on the central nervous system as well as on the renal function. The concentration of lead in blood is the most commonly used biological marker of lead exposure. Owing to the long biological half-life of both cadmium and lead, even a small increase of the daily intake may increase the body burden [18].

The presence of trace metals is an important factor for quality of canned foods. Lead is one of public health interest because of several dangerous effects that it may cause to humans. It is widely dispersed in the environment and exposure to it can increase the number of adverse health effects because of its toxicity after accumulation in multiple organs in the human body [19].

2.1.2 Lead in vegetables and canned foods

According to Chojnacha et al, (2005) it is well known that plants take up metals by absorbing them from contaminated soils as well as from deposits on parts of the plants exposed to the air from polluted environments. The amount of lead taken up and stored in vegetables would vary depending on the type of vegetables, the types of soil, agricultural practices and the amount of lead in the soil [19].

Productions sources could include root vegetables uptake from soil lead, or atmospheric lead deposition onto leafy vegetables. Food is the main source of human exposure to lead. Food may be canned in glass jars or metal containers and require special sealing equipments for consuming. Therefore, there is need for regular monitoring which has sensitive and selective multielement capabilitities of toxic and essential trace elements in canned food products. According to kocak el al in Turkey (2005) has determined lead and other essential trace element in canned vegetable foods by differential pulse paleography (DPP). They found that Pb levels were 0.524 mg/kg in tin canned okra, 0.372 mg/kg in tin canned sliced tomato, and 0.838 mg/l in glass packaging tomato salsa [8].

In order to provide a scientific basis for the European Commission to review the maximum levels of lead in foodstuffs, the European Food Safety Authority (EFSA) was asked for an updated risk assessment on lead in food. The first evaluation of lead by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) dates back to 1972, when a provisional tolerable weekly intake (PTWI) was set to 3 mg of lead per person, corresponding to 50 µg/kg body weight (b.w.). This value referred to all sources of lead exposure and applied just to the adult population. The PTWI was based on the assumption that an average person absorbs 60 to 70 µg of lead per day (1 µg/kg b.w. per day) and was allocated as follows: 20 µg from air, 10 µg from water and 40 µg from food [16].

According to the FAO/WHO (1999) maintained the provisional tolerable weekly intake (PTWI) of 25µg/kg body weight for lead. JECFA concluded that, "based on a quantitative risk assessment, current levels of lead in food would have negligible effects on neurobehavioral development in infants and children". For example maximum levels for lead in Codex Commodity Standards, in canned tomatoes 1mg/kg , canned carrots 1 mg/kg, orange juice 0.3 mg/kg, tomato juice 0.3 mg/kg [20].

2.1.3 Health effects of lead (Pb)

Lead in the environment is strongly adsorbed by sediments and soil particles, and is therefore largely unavailable to plants and animals. Many of the inorganic salts of lead (lead oxides and sulphides) are not readily soluble in water and are sequestered in sediments. In aquatic systems, uptake is influenced by various environmental factors such as temperature, salinity, pH, and presence of organic matter. Lead accumulates in the liver, kidney, spleen and skeleton. Damage to the nervous system and gastrointestinal symptoms are the main signs of lead poisoning. Lead also interferes with the formation of red blood cells, leading to anemia. It is especially toxic to the growing brain and can affect the behavioral development of young children, even at low concentrations. Lead can pass through the placenta and thus affect a growing fetus. Organic lead compounds are fat- soluble and are more toxic than other forms.

In fish lead accumulates primarily in the gill, liver, kidney and bone. In juvenile fish, lead causes a blackening of the tail followed by damage to the spine. It also reduces larvae survival. Leaded gasoline is the major source of increased environmental levels on a global scale. Other anthropogenic sources include mining and metallurgic industries, ammunition, and trash incineration [21].

2.2 Cadmium

Cadmium is naturally occurring metabolic element used for electroplating and galvanization processes, in the production of pigments, in batteries, as chemical reagent and in miscellaneous industrial processes. Cadmium is a relatively rare element and is not found in the pure state in nature. Cadmium compounds have varying degrees of solubility ranging from highly soluble to nearly insoluble. The solubility would affect their absorption and toxicity. Trace element fertilizer and phosphogypsum might contain high cadmium in horticultural soils. Phosphorous fertilizers could also contain high level of cadmium depending upon the source of rock phosphate used in manufacturing. Beside that cadmium in the atmosphere might be high in the vicinity of industrial activities such as smelting [22].

2.2.1 Cadmium in vegetables and canned foods

Cadmium in the body could come from terrestrial foods, which are plants or meat from animals which had ingested plants grown in Cd rich soil. Thus directly or indirectly, it is the cadmium that was present in the soil and its transfer to food plants together with Cd deposited out of the atmosphere on edible plant parts which established the vast majority of human cadmium intake. It was estimated that 98% of ingested Cd would come from terrestrial foods, while only1% might come from aquatic foods such as fish and 1% might arise from drinking water [23].

The main source of exposure to cadmium for the general population is dietary. Small amounts of cadmium are present in a wide range of foodstuffs. Results of the 1994 Australian Market Basket Survey (AMBS) conducted by the Australia New Zealand Food Authority indicated that the mean weekly intake for cadmium for all age groups did not exceed 3.5 g/kg bw (body weight). The Provisional Tolerable Weekly Intake (PTWI) for cadmium is 7 g/kg bw/week [16].

Potatoes are a major source of cadmium in the Australian diet; however the results of the 1994 AMBS indicated that the average level of cadmium in raw potatoes was 0.033 ppm which is less than the Maximum Permitted Concentration (MPC) for cadmium in potatoes (0.1ppm). Offal and mollusks contain higher cadmium concentrations than other foods, but since they are consumed only in small amounts the proportion of cadmium they contribute to the total dietary intake is low [24].

2.2.2 Health effects

The excessive content of Cd in food was reported to be associated with etiology of a number of diseases, especially cardiovascular and kidney. Prolonged exposure to cadmium can cause deleterious health effects in humans as well as plants and micro-organisms. Metal contamination of garden soils may be widespread in urban areas due to past industrial activity and the use of fossil fuels. Heavy metals may be accumulated by plants irrigated with water containing high concentrations of heavy metal or metal contaminated soil. Potentially toxic metals are also present in commercially produced foodstuffs [12].

Risk assessment strategies are often aimed at population subgroups. It is common practice to identify vulnerable people in society such as young children or the elderly, and assess potential risks to the health of these population subgroups.

Cadmium is toxic to most forms of life. It has a tendency to accumulate in both plants and animals. Mushrooms in particular can be very rich in cadmium. Cadmium is moderately toxic to aquatic invertebrates, reducing their growth and decreasing the survival of larvae. In fish, cadmium poisoning can lead to an ion imbalance and interfere with calcium metabolism. In higher animals, cadmium accumulates in the kidneys and liver, where most of it binds to a special protein that makes the metal harmless to the animal. If the uptake is greater than this natural defense, cadmium can damage the kidneys and upset metabolism of vitamin D and calcium. Kidney damage and a decalcification of the skeleton are the serious chronic effects of high cadmium exposure. Based on human toxicology, cadmium concentrations of 100 to 200 µg/g (wet weight) in the kidneys represent a risk for mammals.

One of the threats to food quality and safety are heavy metals in industrial effluents and from sewage plants. Dietary intake of heavy metals is a substantial risk to the health of those who depend upon the use of contaminated irrigation water to grow crops to meet their food requirements. Heavy metal contamination also can affect plant health and the nutritional value of crops. The extent of contamination in food crops is likely to increase with intensification of production systems, urbanization and industrialization but levels of food contamination are not regularly monitored. Cadmium is a byproduct in the production of zinc and lead, and the hydrometallurgical production of zinc is the most important anthropogenic source to the environment. Other major sources are fossil fuel combustion and waste incineration [21].

2.3 Nickel

Nickel is a hard, silvery metal heavily used in industrial purposes which is also abundant in the earth's crust. It has properties that make it very desirable for combining with other metals to form mixtures called alloys. Some of the metals that nickel is alloyed with are iron, copper, chromium, and zinc. Most nickel is used to make stainless steel. Nickel also combines with other substances such as chlorine, sulfur, and oxygen to form nickel compounds. Many of these compounds dissolve fairly and easily in water and have a characteristic green color. Nickel and its compounds have no characteristic odor or taste. Nickel occurs naturally in the earth's crust, is found in all soils, and is also emitted from volcanoes.

Nickel is released into the atmosphere during nickel mining and by industries that convert scrap or new nickel into alloys or nickel compounds or by industries that use nickel and its compounds. These industries may also discharge nickel in waste water. Nickel is also released into the atmosphere by oil-burning power plants, coal burning power plants, and trash incinerators. Divalent nickel is the primary aqueous form. Nickel is listed by the Environmental Protection Agency as one of 129 priority pollutants, and is considered to be one of the 14 most noxious heavy metals. Nickel is also listed among the 25 hazardous substances thought to pose the most significant potential threat to human health at priority superfund sites [25].

2.3.1 Environmental exposure

Food stuffs naturally could contain small amount of nickel. Chocolate and fats are known to contain severely high quantities. Plants were known to accumulate Ni and as a result the Ni uptake from vegetables would increase. Detergents also might contain nickel. Nickel is found to be more available to plant from soils treated with sewage sludge than from inorganically polluted soils. Dafeleesed (2007) in sudan determined nickel and other heavy metals in selected fresh vegetables, and reported 3.22 mg/kg in carrot, 3.18 mg/kg in garden rocket, 2.29 mg/kg in tomato, and 3.38 mg/kg in sweet pepper [26].

2.3.2 Health effects

The most chronic inhalation exposure involves occupational exposure to nickel dust or nickel vapors resulting from welding Ni alloys. Generally, chronic inhalation exposure to nickel dust and aerosols could contribute to respiratory disorders such as asthma, bronchitis, rhinitis, and sinusitis and preumo coniosis. Nickel absorption from gastrointestinal tract was found to be nickel in vegetables absorbed to a greater extent in an empty stomach. Evidence of a carcinogenic risk through the inhalation of nickel metal dust and some nickel compounds but no evidence of a carcinogenic risk from oral exposure to nickel. The effect of nickel uptake of too large quantities, could lead to higher chances of development of lung cancer, nose cancer, prostate cancer, lung embolism, respiratory failure and birth defects [27].

2.4 Copper

Copper is a reddish metal with a face - centered cubic crystalline structure. It is extremely good conductor of both heat and electricity. Most copper is used for electrical equipment, industrial machinery such as heat exchangers and alloys. Copper is ideal for electrical wiring because it is easily worked, can be drawn into fine wire [28].

2.4.1 Environmental exposure

The principal sources of copper in water supplies are corrosion of brass and copper pipes, fixtures and the addition of Cu salts during water treatment for algal control. It is a nutritional requirement. Lack of sufficient Cu leads to anemia, skeletal defect, nervous system degeneration, and reproductive abnormalities. The safe and adequate copper intake is 1.5 to 3 mg/day [29]. Radwan and salama (2006) in Egypt, determined Cu and other heavy metals in Egyptian fresh vegetables. They reported 1.83 mg/kg in tomato, 1.51 mg/kg in carrot, 5.69 mg/kg in cucumber and 4.48 mg/kg in spinach [1].

2.4.2 Health effect

Toxicity exposur to copper may occur from eating food, drinking water or breathing air with excessive copper content. A small amount of copper may enter the body by skin contact with copper-containing substances. The oral route is the main pathway of exposure to the element. Food and water are the predominant sources of copper intake. Food may account for over 90% of copper intake in adults if water has low copper content (< 0.1 mg/L). If water copper content is higher (1-2 mg/L) it may account for up to 50% of total intake. In infants consuming copper supplemented artificial formula, the contribution of water may be less than 10% whereas, if the formula is not fortified with copper, water may contribute over 50% of total copper intake, especially when water copper content is 1-2 mg/L. Acute copper toxicity is infrequent in man, and usually is a consequence of ingesting contaminated. Foodstuffs or beverages (including drinking water), and from accidental or voluntary ingestion of high quantities of copper salts. Acute symptoms include salivation, epigastric pain, nausea, vomiting and diarrhea. Intravascular hemolytic anemia, acute liver failure, acute renal failure with tubular damage, shock, coma and death has been observed in severe copper poisoning. There are some reports in humans, suggesting that the consumption of beverages or drinking water contaminated with copper results in nausea, vomiting, and diarrhea. Long term toxicity of copper has been less studied [30].

4. Conclusion

Food safety is a major public concern worldwide. During the last decades, it was associated with consumption of food stuffs contaminated by pesticides, heavy metals and/or toxins. Heavy metals are among the major contaminants of food and may be considered as major problem to our environment. Such problem is getting more serious all over the world especially in developing countries. Heavy metals in general are not biodegradable, have long biological half- life and have the potential for accumulation in different body organs leading to unwanted side effects.

Heavy metals are potential environmental contaminants with the capability of causing human health problems if present to excess in the food we eat. They are given special attention throughout the world due to their toxic effects even at very low concentrations.

Vegetables are vital to human diet as they contain essential components needed by the human body such as carbohydrates, proteins, vitamins, minerals and also trace elements. Consumption of vegetables is one of the pathways by which heavy metals enter the food chain. Excessive accumulation of dietary heavy metals can lead to serious health problems. Lead and cadmium are among the most abundant heavy metals and are particularly toxic. The excessive content of these metals in food is associated with etiology of a number of diseases, especially with cardiovascular, kidney, nervous as well as bone diseases. In addition, they are also implicated in causing carcinogenesis, mutagenesis and teratogenesis.

In order to eliminate the surface pollution from vegetable thoroughly effective washing must be done with clean water. It is clear from this study that even motor vehicle emissions can be a source of heavy metal contamination in vegetables at road side market. Vegetable farms must be irrigated with safe water, avoiding industrial effluents and sewage disposals. Use of good agricultural practices under supervision for proper fertilizer application has to be exercised. Vegetables must be displayed in clean, healthy and well protected places away from roadways and industrial areas.

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