UNIT 6 FOOD CONTAMINANTS

Structure

6.1 INTRODUCTION

The food that we eat is the source for all the nutrients required by our bodies to grow and survive. Foods also contain a wide range of natural chemical compounds which have no nutritional function. Some of these compounds may even act as anti-nutritional factors, interfering with the utilization of some of the nutrients present in these foods, while others may be potentially toxic, resulting in illness and death, if consumed in large quantities. Food can also become contaminated with harmful substances while it is still in the fields, or while being transported, stored or processed for consumption. In this unit, we will look at the different types of contaminants that can enter the food chain and how they can affect the quality of the food and our health. It is also important to know what we can do to reduce our exposure to these contaminants. This is the other aspect discussed in this unit.

Objectives

After studying this unit, you will be able to:

- list some naturally occurring toxicants in plant and animal foods,
- define and give examples of some anti-nutritive compounds in foods,
- enumerate the various types of environmental food contaminants,
- discuss the harmful effects of the different types of toxicants and contaminants present in our foods, and
- suggest ways to reduce our exposure to various food contaminants.

6.2 FOOD CONTAMINATION

Food, as we all know, is any edible substance, ice, beverage or ingredient used or intended for use or for sale in whole or in part for human consumption. *Contamination* means exposing food to filth, toxic substances, manual contact during service or preparation if such food will not be subsequently cooked prior to service, rodent or insect contact or infestation, or any condition which permits introduction of pathogenic

microorganisms or foreign matter. In simple terms, the presence in food of harmful, unpalatable, or otherwise objectionable foreign substances, this may be chemicals, microorganisms or diluents, before, during, or after processing or storage, is *food contamination.*

Codex Alimentarius (or food code elaborated by the Codex Alimentarius Commission of the Food and Agriculture Organization and World Health Organization) defines 'food contamination' *as any substance not intentionally added to food, which is present in such food as a result of the production (including operations carried out in crop husbandry, animal husbandry and veterinary medicine), manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food as a result of environmental contamination.*

In day to day practice, our food can get contaminated by the water used for cooking or washing, by the soil in which the food is grown, by the container used for storage, preparation and service, by the personnel handling the food at various stages etc. During recent years, the problem of dioxin contaminated chickens, hormone injected cattle, genetically modified varieties of maize such as star link, animal carcasses used to make animal feed and subsequent mad cow disease among animals consuming such feed, pesticide residue containing mineral water and soft drinks of popular brand etc. had received considerable media attention. The list of contaminated food is getting longer and longer.

Contaminants in foodstuffs can chiefly be classified as physical, biological and chemical contaminants. *Physical contaminants* include extraneous matter such as sand, soil, hair etc. *Biological contaminants* consist of microorganisms such as fungi and their metabolic products. *Chemical contaminants*, on the other hand, are the products of fast growing modern technology. The increasing population, as well as, the mass migration into the cities, demands a massive and rapid increase in our food supply. Increased agricultural productivity requires constant large scale application of fertilizers, insecticides, pesticides, antibiotics and chemicals for stimulating the growth of plants and farm animals. Residues, sometimes at toxic levels, from most of these products, end up in the food supply via the soil, air and water. Chemical contaminants may also come from other sources besides agriculture. Modernization of the population's lifestyles also has resulted in the production of synthetic chemicals for use in all aspects of modern life – in industry, transportation, housing, household activities, entertainment, leisure activities, education and research.

You would realize some of these contaminants may be naturally occurring in foods, others may be environmental contaminants while some may be intentionally added to adulterate food about which we will learn in the next unit. Here we will focus on all contaminants, natural or otherwise found in foods. For your convenience we have classified them as under:

- *Naturally occurring toxicants*, including toxicants in plant, animal food and anti-nutritional factors in foods.
- *Environmental contaminants*, including biological contaminants, pesticide residues, veterinary drug residues and heavy metals.
- *Miscellaneous*, including dioxins, acrylamide, contaminants from plastic etc.

Let us learn about these contaminants next.

6.3 NATURALLY OCCURRING TOXICANTS

Some of the foods contain naturally occurring toxic compounds, which man has identified by experience and learnt to avoid. Naturally occurring toxicants are products

of the metabolic processes of animals, plants and microorganisms from which food products are derived. Many of these substances in food products are potent poisons, which produce under certain conditions, severe if not fatal symptoms. In several cases, man has tried to develop methods to process the food to remove the toxic compounds and has been able to consume the detoxified food. Unfortunately, some of these compounds have delayed toxicity, and the recognition of their presence in food, as well as, the cause and effect relationships between the observed poisoning and the food is often slow in coming. Hence, we need to be aware of the presence of these food toxicants and their harmful effects.

The naturally occurring toxicants as indicated in the Figure 6.1, are being discussed in the following three sections. The first two sections deal with potential toxins in animal and plant foods which have resulted in serious disease conditions in man while the third section is devoted to toxins which behave as anti-nutritional compounds.

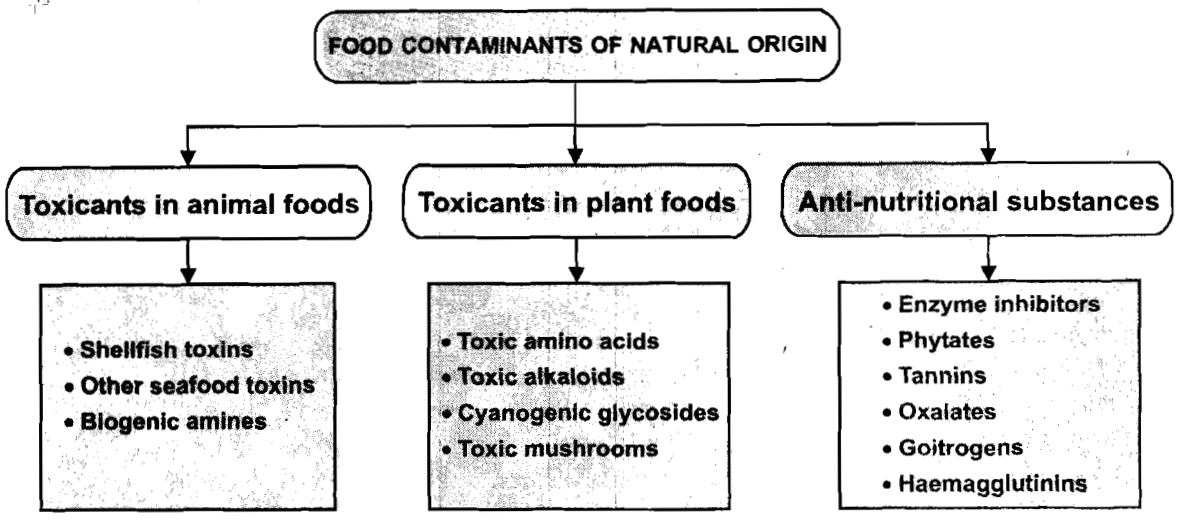

Figure 6.1: Naturally occurring toxicants

6.3.1 Toxicants in Animal Foods

There are a number of cases of food poisoning originating from seafood and shellfish. We shall learn about the toxins present in these foods next.

Seafood Toxins

Some of the most potent toxins are found in marine products, especially *shellfish*. The bulk of shellfish poisonings classified are infectious in nature. This can be *bacterial or viral in nature, with the Norwalk virus* most likely accounting for the bulk of the gastroenteritis cases. The next question, which then comes to our mind, is how does shellfish poisoning occurs? Shellfish such as clams, oysters, scallops and mussels feed on the plankton and algae in the sea. Some of this plankton is toxic for us but not for the shellfish. Poisoning results from consuming shellfish which has fed on this toxic plankton. Figure 6.2 illustrates different types of shellfish.

What are the consequences of shellfish poisoning? Four separate types of poisonings due to ingestion of toxins in shellfish have been identified. They are *paralytic, neurologic, diarrhoeal and amnesic shellfish poisonings*, depending on the kind of symptoms that develop. Let us go through these in detail.

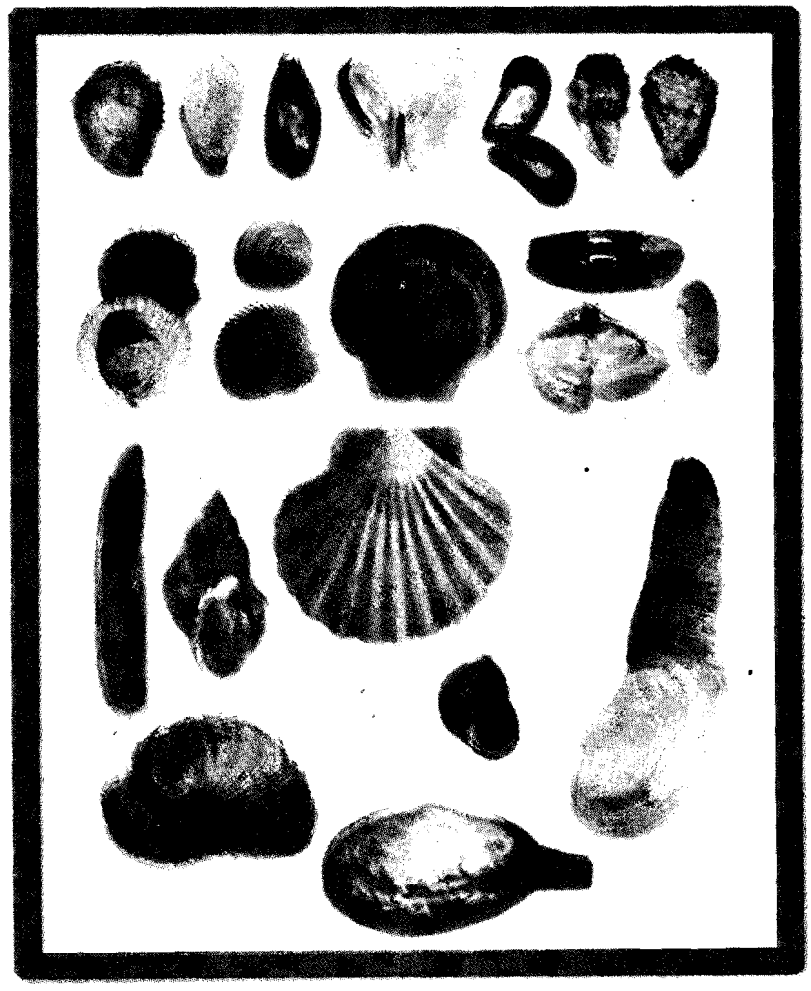

Figure 6.2: Different shellfish

- *Paralytic shellfish poisoning (PSP):* It causes the most severe symptoms of all the shellfish poisonings. The causative agent is *saxitoxin*. It is a powerful neurotoxin produced by *Gonyaulax catenella*. Initial symptoms of poisoning, which can be seen within 30 minutes of consuming such shellfish, include headache, a floating feeling, dizziness, tingling, burning, numbness in the extremities, which spreads quickly throughout the body producing a general lack of muscular co-ordination. Muscle weakness causes difficulty in swallowing or speaking. Abdominal symptoms such as nausea, vomiting and diarrhoea can also occur. It could also result in death due to paralysis of the respiratory system.

- *Diarrhoeic shellfish poisoning:* It is characterized by mild gastrointestinal disorder caused by high molecular weight polyethers produced by dinoflagellates.

- *Neurotoxic shellfish poisoning:* It causes both gastrointestinal and neurological symptoms and occurs due to the exposure to a group of polyethers produced by dinoflagellates.

- *Amnesic shellfish poisoning:* It is characterized by gastrointestinal and neurological disorders and is caused by the presence of an unusual amino acid as contaminant of shellfish from diatoms.

Contrary to a common belief, algal blooms (red tides) are not well correlated to outbreaks of shellfish poisoning. Shellfish poisoning can occur in the absence of a red tide, conversely, red tides do not necessarily mean that shellfish are poisonous. Despite folklore that contends that shellfish are universally safe if eaten during months containing the letter 'r', correlation between outbreaks of shellfish poisoning

and water temperature is poor. The incidence of shellfish poisoning has been declining, most likely because of careful monitoring and improved public awareness all over the world.

Next, let us look at some of the other well known toxicants present in seafood.

Ciguatera

Ciguatera probably represents the most common cause of poisoning from fish in tropics. Ciguatera comprises over 50% of all reported cases of seafood poisoning. This poisoning is very common in temperate and inland areas. Ciguatera toxin, *a polyether*, is found in blue-green algae and protozoans and is known to affect thermoregulation and sensory, motor and muscular activities. These organisms are ingested by herbivorous fish, which, in turn, are eaten by larger fish. Ciguatera is concentrated in the flesh, adipose tissue and organs of the larger fish. Ciguatera toxin is odourless and tasteless, and contaminated fish tastes normal. What is more important, here is the fact that the toxin is heat stable and thus may affect people even if fish are prepared properly. Further, ciguatera toxin is secreted into breast milk and freely crosses the placenta, affecting the foetus. Symptoms usually are evident within 2-6 hours after ingestion and may last as long as 48 hours. It produces a spectrum of illness that is not easy to understand. Over 150 symptoms have been described, involving multiple body systems: gastrointestinal, neurological, musculoskeletal, dermatological and cardiopulmonary. Symptoms generally consist of abdominal cramps, nausea, vomiting, profuse watery diarrhoea, myalgias (pain in the muscle), arthralgias (neuralgic pain in a joint or joints), weakness and dysuria (painful or difficult urination). Neurologic symptoms tend to occur later (up to 72 h) and may persist for months. These are predominantly paresthesias (a skin sensation, such as burning, prickling, itching, or tingling), but a myriad of other sometimes bizarre neurologic symptoms also may be observed, including sensation of loose painful teeth, tingling in the lips, tongue and throat, vertigo, ataxia, visual changes and seizures. Death is rare, with a reported mortality rate of approximately 1 in 1000 patients. Contrary to *saxitoxin,* the *cigutera* toxin is more potent. In fact, saxitoxin is a derivative of ciguatera toxin.

Scombroid

Ingestion of improperly handled and stored seafood (yellow-fin tuna, skipjack, bonit and mackerel) causes scombroid poisoning. *Maitoxin* has been implicated in scombroid poisoning, which releases neurotransmitters and increases the contraction of smooth, cardiac and skeletal muscle. Decarboxylation of histidine, a aminoacid, naturally found on fish, into biogenic amines, such as histamine, occurs at temperatures greater than 15°C. Histamine, an organic compound, derived from histidine is released from certain cells upon tissue injury or during the activity of certain antibodies. *At high concentrations, they are risk factors for food intoxication whereas moderate levels may lead to food intolerance.* Histamine is not inactivated by heat, therefore, proper cooking is not a remedy for improper storage. Patients sometimes describe a peppery or bitter taste to the fish, but often the fish tastes completely normal.

A host of symptoms, including skin flushing, facial swelling, dizziness, throbbing headache, oral burning, metallic, sharp or peppery taste in mouth, abdominal cramps, nausea, vomiting, diarrhoea, palpitations, a sense of unease, and, rarely, prostration or loss of vision characterize scombroid poisoning. A rash that looks like sunburn may occur and a small number of patients have *hives*, i.e., allergic skin reaction. Symptoms usually occur within 10-30 minutes of ingesting fish and generally are self-limited. Physical signs may include a diffuse erythema (a reddening of the skin due to capillary dilation), tachycardia, wheezing and hypotension or hypertension. Scombroid is second in incidence only to ciguatera poisoning, however, it often is misdiagnosed because it resembles an allergic reaction. Best precaution, therefore, is to avoid organ meats and gonads.

Before, we move further, we would like to elobrate further on the biogenic amines. What are biogenic amines? The biogenic amines are biologically active compounds

synthesized from amino acids. Foodborne biogenic amines are most commonly synthesized by spoilage microorganisms and are usually considered to be potential toxins. Biogenic amines should not always be considered to be potential toxicants but can also be considered to be non-hormonal growth promotants.

In our discussion above, we studied that in addition to the release of endogenous histamine during allergic reactions, certain foods contain histamine produced by decarboxylation of histidine by enzymes produced by bacterial contamination of foods.

An example of latter mechanism is scombroid poisoning, which is one of the three most common illnesses associated with seafood consumption. Other biogenic amines such as *putrescine* and *cadaverine* may play a synergistic role with histamine by inhibiting the histamine detoxifying enzymes, diamine oxidase and histamine N-methyltransferase. While allergic reactions affect only susceptible individuals, the contamination of foods with histamine will cause symptoms in all individuals exposed to sufficient amounts of the food involved.

Pufferfish poisoning

Tetrodotoxin (TTX) causes pufferfish (tetrodon) poisoning, also known as *blowfish poisoning or fugu*. How does a pufferfish look like? Well, a typical pufferfish is shown in the Figure 6.3. TTX is one of the most potent non-protein neurotoxin found in nature that blocks sodium channels of excitable cells and exposure can result in rapid death. Symptoms occur within 15 minutes of ingestion but may be observed as late as several hours later. More rapid onset of symptoms is associated with higher levels of toxin ingestion. Symptoms principally are neurologic and cardiovascular in nature and may include peri-oral (around the mouth) tingling, a floating sensation, a feeling of overall warmth, weakness, incoordination, slurred speech, bradycardia (slow heart rate), hypotension and dyspnea (shortness of breath). Decreased levels of consciousness, seizures and death have occurred in as few as 17 minutes. TTX is concentrated in organ meat and gonads. Best precaution, therefore, is to avoid eating the organ foods.

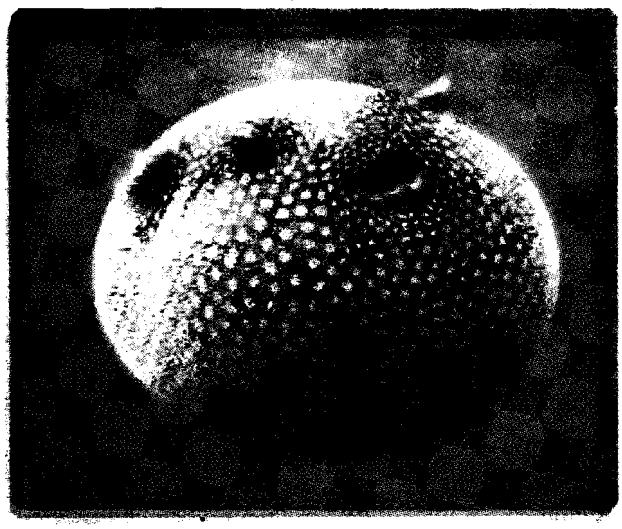

Figure 6.3: Pufferfish

Hallucinogenic fish poisoning

Hallucinogenic fish poisoning can occur with the ingestion of a number of fish species. *Indoles* with similar effects to the notorious drug lysergic acid diethylamide (LSD) have been implicated with sources in algae and plankton. Hallucinations occur in isolation with no other symptoms.

The symptoms of acute poisoning include nausea, vomiting, occasional diarrhoea, sweating, headache, hypertension, tachycardia (very rapid heart beat) and twitching

among other symptoms. Vasodilation (dilation of blood vessels), hypertension and respiratory depression may occur at doses 20-60 mg/kg. Bradycardia may be present at higher doses. Convulsions and coma have been reported. Effects on the central nervous system may include euphoria, hyper excitability and alertness, rambling speech, deliria, uncontrollability, transcendental mood, distractibility, depersonalization and impairment of judgement. A temporary psychotic state with sensory illusions, distortions or visual hallucinations consisting of shimmering intensification of colour and texture, brightly coloured lights, geometric designs, animals and occasionally human images may occur. Hearing or tasting colours and seeing sounds have been reported. Rarely, anxiety, fearful auditory, visual and tactile hallucinations, panic states and paranoid delusions, suspiciousness, emotional liability, intense depression, loss of control, suicidal ideation and self destructive or aggressive acts may occur. Deaths have resulted from hallucinatory effects leading to accidental death.

Miscellaneous shellfish poisonings

Other shellfish poisonings include oyster, abalone and red whelk poisoning. Sea urchin gonads contain an acetylcholine like substance that produces symptoms including salivation, nausea, vomiting, diarrhoea and abdominal pain. *Starfish ingestion may be associated with nausea and vomiting as a result of asteriotoxin.*

The discussion above was an elaborate compilation of toxicants found in animal foods, mainly sea food. Next, let us review the toxicants in plant foods which contaminate the foods.

Check Your Progress Exercise 1

1) Define the term 'Food Contamination'? What are the three main types of contaminants present in our foods?

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2) What are naturally-occurring toxicants?

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3) Mention the different types of shellfish poisonings.

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4) List the symptoms of the following poisonings:

a) Ciguatera poisoning

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b) Scombroid poisoning

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6.3.2 Toxicants in Plant Foods

Several foods, some of which we consume regularly, have toxic compounds in them which are best avoided. These compounds can be proteins, amino acids, alkaloids or cyanogenic glycosides in nature. You would recall studying about a few of these in Unit 4. Let us have a look at the different toxicants which have been identified in foods for human consumption.

Favism is a condition characterized by haemolytic anaemia (breakup of red blood cells) after eating fava beans. Fava beans, which are a major protein source for the Middle and Far East and North Africa, are a hazard for those individuals who have a deficiency of the enzyme *glucose-6-phosphate dehydrogenase*. Initial symptoms of the disease *favism* caused by eating these beans include headache, nausea, vomiting, pain and fever. This is followed by haemoglobin in the urine resulting from a rapid breakdown of red blood cells, jaundice and death.

Gossypol, another toxicant is present in cotton seed and may come into the cotton seed oil if it is not treated properly. *Erucic acid*, which has been linked to heart disease, is found in mustard and rapeseed oil. In fact, the consumption of bitter cucumber, bitter squash zucchini and other cucurbits has resulted in symptoms of severe cramps, diarrhoea and collapse. This is because of the increased levels of the toxin *cucurbitacins* in the bitter cucurbits. Bitter cucurbits, should, therefore, not be eaten.

Let us look at some specific toxicants found in plant foods. You may recall reading about these earlier in Figure 6.1.

A) *Toxic amino acids*

Lathyrus sativus (kesari dhal) seeds contain toxic amino acid *beta-oxalyl aminoalanine* (BOAA), is considered to be responsible for the disease lathyrism. It is an *excitotoxin*, which is a toxin capable of over stimulating and destroying nerve cells, thus contributing to the development of the uppermotor neuron disease. The disease has been especially occurring in parts of the States Madhya Pradesh, Chattisgarh, Bihar, Maharashtra and in countries like Bangladesh where the pulse used to be consumed in larger quantities. The classical symptom is the *spastic paraplegia*, the paralysis of lower limbs as you may recall reading earlier in Unit 5, sub-section 5.7.1. Consumption of the pulse in lower quantities would result in painful spasms in the calf muscles, heaviness of the lower limbs, pain in the knee and ankle joints and difficulty in walking. The toxic amino acid from *Lathyrus sativus* can be reduced by steeping the seeds in water and discarding that water, or by using a process similar to parboiling of paddy. It is, however, advisable to avoid consuming this dhal.

B) *Toxic alkaloids*

Alkaloids are the *nitrogen heterocycles which occur mainly in plants as their salts of common carboxylic acids such as citric, lactic, oxalic, acetic etc.* Their amine character produces an alkaline solution in water, hence the origin of their name - *alkaloids*.

When eating potatoes, you must have been told to avoid green potatoes or the green and damaged portions of potatoes. This is because potatoes contain toxic compounds known as *glycoalkaloids e.g. solanine*, which are concentrated in the green portions and also the peel of the tuber. Alkaloids are the *nitrogen heterocycles which occur mainly in plants as their salts of common carboxylic acids*. They impart a bitter taste to the potatoes. Symptoms of poisoning, which develop after consuming such green potatoes or the skin of potatoes are diarrhoea, vomiting, severe abdominal pain, apathy, restlessness, drowsiness and visual disturbance. To minimize the hazard, insect attack to potato tubers during growing, mechanical damage during harvesting and storage have to be avoided.

Contamination of food products may also occur when certain toxic plants may be harvested or mixed with the edible species unintentionally. For instance, the seed of *Argemone mexicana,* a seed with toxic alkaloid compounds e.g. *sanguinarine*, resembles the seed of mustard which we use for seasoning in our cooking, as well as, for extraction of mustard oil. The argemone plant grows wild as a weed alongside mustard in the fields and may accidentally be harvested with the mustard. Consumption of mustard oil contaminated with argemone oil can lead to a condition known as *epidemic dropsy*, in which there is oedema over ankles, gastrointestinal disturbances and vascular and cardiac complications, which can result in death. We will learn more about this condition in Unit 8, Food Adulteration, as argemone oil is often intentionally added to mustard oil by traders to increase their profit margins.

There are several other examples of food being contaminated with toxic weeds and resulting in serious ailments. *Veno-occlusive disease (VOD)* of the liver is a well known form of liver injury produced by *pyrrolizidine group of alkaloids* as you may recall studying in Unit 5. In one such outbreak in the tribal areas of Madhya Pradesh, millet called *gondhli (Panicum miliare)* consumed by the tribals got contaminated with the toxic weed seeds of *Crotalaria nanaburn.* The tribals consequently suffered symptoms of ascites (fluid accumulation in the abdominal region), pain in the stomach and several of them subsequently died. Such a form of contamination is easily prevented by removal of the toxic plant in the fields by de-weeding. If the contamination is found in the grains before consumption, the toxic grains could be removed either by winnowing or hand picking.

Cyanogenic glycosides

Cyanogenic glycosides are present in a number of food plants and seeds. *Cassava* is a staple dietary item in tropical Africa, South America and South East Asia. The plant is a rich source of cyanogenic glycosides, which may be hydrolysed chemically or enzymatically to yield the poisonous *hydrogen cyanide*. Signs and symptoms of acute cassava poisoning are headache, breathlessness, gasping, paralysis, muscle weakness, coma and death. *Linamarin*, a cyanogenic glycoside, can be removed from cassava by leaching out with water. In fact, cassava is consumed only after treatments like soaking, fermentation and drying which will minimise the amount of toxin in the root. It can be detoxified by chopping and grinding in running water prior to preparation.

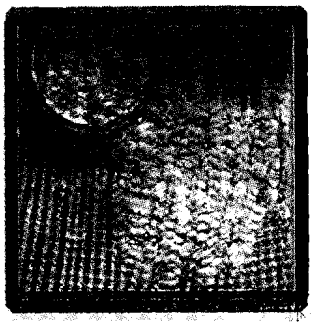

Figure 6.4: Lima beans

Lima beans as illustrated in the Figure 6.4, contain a high concentration of cyanide precursors. These inhibit the oxidative processes of cells causing them to die very quickly. Because the body rapidly detoxifies cyanide, an adult human can withstand 50-60 ppm for an hour without serious consequences. However, exposure to concentrations of 200-500 ppm for 30 minutes is usually fatal. Other foods rich in cyanide are apple seeds, bitter almonds and laetrile, the bogus cancer remedy produced from peach kernels. Consumption of these foods has resulted in cases of severe illness and even death.

Mushroom Poisoning

Mushroom poisoning is caused by the consumption of raw or cooked fruiting bodies (mushrooms, toadstools) of a number of species of higher fungi. Figure 6.5 shows a variety of mushrooms, of which some could be poisonous as well. The term *toadstool* (from the German word *Todesstuhl*, meaning death's stool) is commonly given to poisonous mushrooms, but for the individuals who are not experts in mushroom identification, there are generally no easily recognizable differences between poisonous and non poisonous species. The toxins involved in mushroom poisoning are produced naturally by the fungi themselves, and each individual specimen of a toxic species should be considered equally poisonous. Most mushrooms that cause human poisoning cannot be made non toxic by cooking, canning, freezing, or any other means of

processing. Thus, the only way to avoid poisoning is to avoid consumption of the toxic species.

Figure 6.5: Variety of mushrooms

Mushroom poisonings are generally acute and are manifested by a variety of symptoms, depending on the amount and species consumed. There are four categories of mushroom toxins:

- *protoplasmic poisons* (poisons that result in generalized destruction of cells, followed by organ failure)
- *neurotoxins* (compounds that cause neurological symptoms such as profuse sweating, coma, convulsions, hallucinations, excitement, depression, spastic colon)
- *gastrointestinal irritants* (compounds that produce rapid, transient nausea, vomiting, abdominal cramping and diarrhoea), and
- *disulfiram - like toxins*. Mushrooms in this last category are generally non-toxic and produce no symptoms unless alcohol is consumed within 72 hours after eating them, in which case, a short-lived acute toxic syndrome is produced.

Next, let us learn about the anti-nutritional factors in foods, which can cause food contamination.

6.3.3 Anti-nutritional Factors in Foods

Many foods, particularly those of plant origin, contain a wide range of anti-nutritional factors which interfere with the assimilation of nutrients by our body. Some of the

important anti-nutritional factors are protease inhibitors, phytates, oxalates, tannins, lectins and goitrogens etc. as highlighted in Figure 6.1.

Here, let us see how they can be a cause for concern.

A) *Protease inhibitors*

Protease inhibitors are the compounds which are found to some extent in cereal grains such as oats, wheat, barley and maize; vegetables such as onion and beetroot; nuts such as peanuts. These inhibitors interfere with the action of enzymes *trypsin* and *chymotrypsin* produced by the pancreas to break down ingested proteins.

Trypsin inhibitors are proteins distributed widely in the plant foods like legumes and certain animal foods like white of an egg. They generally inhibit the activity of trypsin (an enzyme secreted by the pancreas) in the gut and interfere with the digestibility of dietary proteins, thereby, reducing their utilization. The trypsin inhibitors present in the *dhals* that we eat daily and the hen egg white, are easily inactivated by the normal cooking procedures and do not pose any problem. More drastic heat treatment is necessary to inactivate these inhibitors in soyabeans, peas, lima and kidney beans and also the duck egg white. Thus, for better digestibility and utilization of the proteins, these foods need to be thoroughly cooked before consumption.

Raw soybeans too have high levels of trypsin inhibitors. These can cause growth retardation and hypertrophy of pancreas. It hampers the release of essential amino acids like methionine. The trypsin inhibitors are generally heat labile and are largely destroyed in the normal process of cooking.

B) *Haemagglutinins*

Haemagglutinins are the globulin type of proteins which are present in the seeds of plants like double bean, field bean, white bean and horse gram, which have the property of agglutinating RBCs (Red Blood cells). The agglutinins combine with the cell lining of the intestinal wall and thus interfere with the absorption of essential nutrients. Consumption of improperly processed beans result in symptoms such as nausea, vomiting and diarrhoea. It also leads to growth depression, a decrease in food intake and death.

C) *Phytates*

Phytates are widely distributed in seeds of vegetables, fruits and grains. Unrefined cereals and millets are the richest sources of phytates. Refined or polished cereals, like rice, have lower levels of phytates. The phytates present in cereals form insoluble complexes with the minerals such as iron, magnesium, zinc and calcium and contribute significantly to their poor absorption from the cereal-based diets. You may recall reading in the Advance Nutrition Course about phytate as an inhibitor present in cereals which prevents the absorption of iron. Germination or overnight soaking of grains reduces the phytate content considerably because of breakdown of the phytate by enzymes which can do their 'cleaving' job in presence of water or moisture. This also improves the availability of minerals in the grains.

D) *Tannins*

Tannins are another class of compounds which interfere with the absorption of minerals like iron and reduce the availability of proteins by binding to them. These are widely distributed in the plant kingdom and are present in high amounts in the seed coat of most legumes, spices, tamarind, turmeric, certain vegetables, fruits and particularly the tea. Millets like *bajra, ragi, sorghum* also contain a fair amount of tannin. A typical Indian diet based on cereals, legumes, vegetables and spices may contain as much as 2-3 g of tannin. Removal of seed coat of legumes, exclusion of tamarind and avoiding tea with meals may improve iron absorption from the diet by reducing the tannin content of the diet.

E) *Oxalates*

Oxalates are widely distributed in plant foods mostly in the form of calcium salts. Oxalates are known to interfere with calcium absorption. High intake of oxalates increases their excretion in the urine, which in turn, may predispose the person to urinary stones. Rich sources of oxalates are green and leafy vegetables and some legumes like *horsegram* and *kesari dhal* (*Lathyrus sativus*).

F) *Goitrogens/anti-thyroid substances*

Goitrogens/anti-thyroid substances present in certain plant foods have been found to interfere with the uptake of iodine by the thyroid gland in the body. This can contribute to the development of iodine deficiency disorders when iodine intakes are marginal. *Thiocyanates, isothiocyanates* and their derivatives are the chief goitrogens which occur in leaves and vegetables belonging to the *Brassica* genus and family *Cruciferae,* like radish, cabbage, cauliflower, rapeseed, mustard, broccoli, brussels sprouts, turnips, etc. Soyabean and other legumes, *bajra*, peanut and lentils also contain goitrogens. The enzymes required for production of goitrogens in the plant are destroyed by cooking. Goitrogens are also lost through leaching into cooking water.

G) *Other substances*

Legumes contain a wide range of some other biologically active and anti-nutritional components. These include *oestrogenic isoflavones, coumestans* (linked with reproductive disturbance in mammals) and *saponins*. However legumes are a rich source of proteins and minerals for humans and can be safely eaten daily. The only precaution to be taken is that they should be thoroughly cooked before eating, as cooking destroys most of the anti-nutritional factors.

In fact, the presence of anti-nutritional factors does not mean that we stop consuming the above mentioned foods. Trypsin inhibitors, as mentioned before, are easily destroyed by cooking, germination of grains reduces the phytate content, removing the seed coat of legumes and decreasing the intake of tea and tamarind can easily decrease the intake of tannins. Only excessive intake of foods containing goitrogens in the face of marginal intake of iodine from foods and water may lead to precipitation of iodine deficiency disorders. Hence, a little care and precaution can help us overcome the problem of contamination, if any caused by these substances.

Check Your Progress Exercise 2

1) List four toxicants which have been identified in plant foods for human consumption.

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2) What is mushroom poisoning? How can it be avoided?

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3) What are anti-nutritional compounds? Give some examples.

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4) Match the following foods to the toxins they contain:

	Food		*Toxin*
i)	Cassava	a)	Cucurbitacins
ii)	Fava beans	b)	BOAA
iii)	*Lathyrus sativus*	c)	Solanine
iv)	Potato	d)	cyanide precursors
v)	Cucumber	e)	Linamarin

5) Match the following anti-nutritional compounds to the harmful effect caused by consuming them in excessive amounts:

	Anti-nutritional Compound		*Toxic effect*
i)	Phytate	a)	predisposes to urinary stones
ii)	Oxalate	b)	interferes with digestibility of dietary protein
iii)	Goitrogens	c)	causes poor absorption of iron, zinc and calcium
iv)	trypsin inhibitor	d)	predisposes to iodine deficiency disorders

Having read about the naturally occurring toxicants, next in the last section, we move on to the environmental contaminants.

6.4 ENVIRONMENTAL CONTAMINANTS

Contamination of foodstuffs can occur from different sources in the environment as illustrated in Figure 6.6.

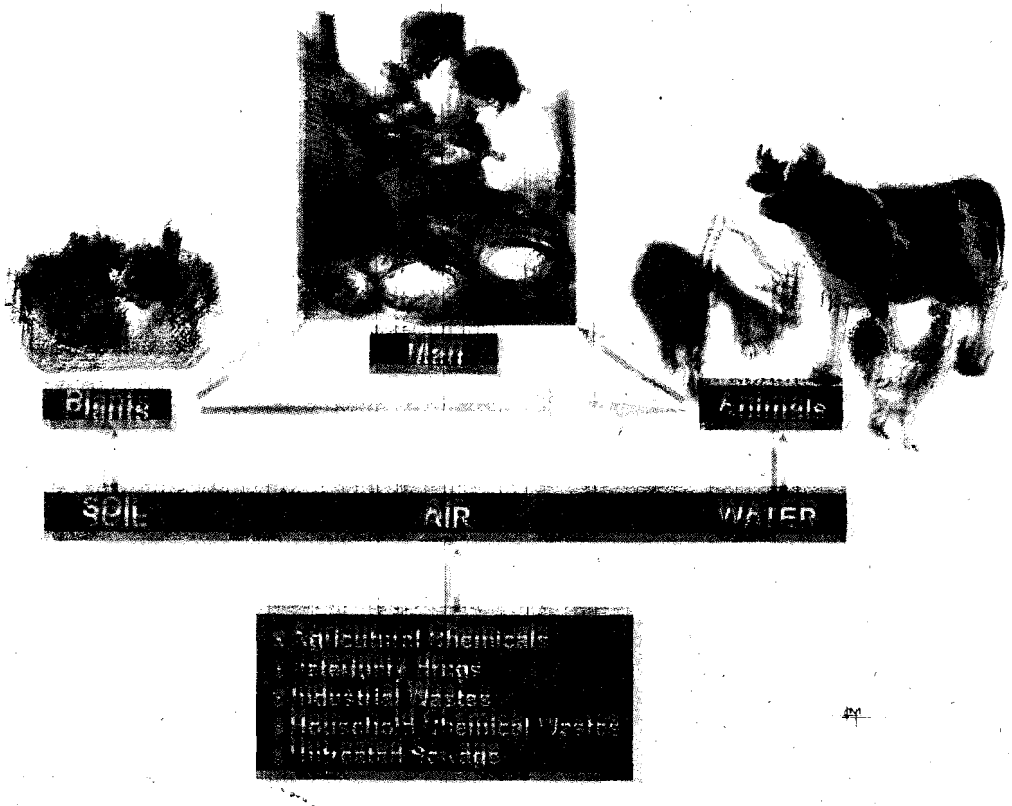

Figure 6.6: Sources of food contamination

As illustrated in Figure 6.6, industrial effluents, untreated sewage and household chemical wastes (detergents, soaps, pesticides, discarded batteries, etc.) and residues of pesticides, fertilizers and veterinary drugs used in agriculture and animal husbandry, may find their way into soil, water and air. These toxic chemicals present in the soil, water and air are taken in by the plants and by land and marine animals. For example, selenium, arsenic, fluorides, nitrates in the soil may accumulate in plants to toxic levels. Indirect contamination of meats, milk or eggs may occur as a result of ingestion of contaminated plants by animals. Since man is on top of the food chain, he is the worst affected. Many instances of man being poisoned as a result of indirect contamination of food are recorded in literature. In fact, one of the oldest accounts of poisoning is mentioned in the Bible. It is said that the Hebrew were poisoned after consuming quails. Normally quail flesh can safely be eaten. However, in this case, it was suggested that the toxicity resulted from the quails having earlier eaten hemlock seeds, which are poisonous.

In the coming sections, we will discuss about the different types of environmental contaminants. These are:

- *biological contaminants* – like fungi and fungal toxins, bacteria and their toxins due to improper storage or processing of the food products
- *pesticide residues* – found in milk, grains, oil, bottled water, vegetables and fruits
- *veterinary drug residues* – found in milk and milk products, meat and meat products
- *metallic contaminants* – e.g. nickel due to the improper processing of *vanaspati, suji,* from rollers used in processing etc.

We shall begin with microbial or commonly referred to as biological contaminants.

6.4.1 Biological Contaminants

You may recall reading about food borne diseases caused by the consumption of contaminated food items in the last unit. In the developing countries, food-borne diseases continue to be a serious health hazard and a major cause of morbidity and mortality. In fact, they are a major public health concern, which cut across national boundaries in terms of human ailments and economic loss. Most of the reported cases of food-borne diseases are due to the consumption of food contaminated with microorganisms. Microorganisms present in the soil, water and air may infect the growing plant and stored foodstuffs and produce harmful metabolites. Warm temperatures and high moisture content serve as ideal conditions for the growth of microorganisms like bacteria and fungi in stored food products. These types of contaminated foodstuffs have been the cause of many serious poisonings in man and animals which have even resulted in death.

Toxins produced by fungi are collectively termed as *mycotoxins* and the disease caused by them as *mycotoxicosis*. You have already read about them in the last unit. Mycotoxins have been found in many types of foods for human consumption, particularly cereals and nuts. Contamination can occur in the field or during storage. Meat, eggs and milk from animals that have fed on mycotoxin contaminated feed can provide an indirect route of exposure for us. Some examples of mycotoxins, you may recall, are aflatoxins produced by the fungi *Aspergillus flavus* and *Aspergillus parasiticus*, deoxynivalenol, fumonisin and zearalenone produced by the *Fusaria* species and ergot alkaloids produced by *Claviceps* spp. and ochratoxin by *Aspergillus ochraceus* and *Penicillium* species.

The foods which are at a risk for aflatoxin contamination include a wide range of commodities like maize, groundnut, dried coconut, cottonseed and spices like chilli, pepper. Coffee may contain ochratoxin and deoxynivalenol in wheat.

There have been a few recorded outbreaks as a result of fungal contamination in India. Consumption of *bajra* contaminated with ergot, derived from the fungus *Claviceps fusiformis,* has been implicated in a disease outbreak characterized by symptoms of nausea, vomiting, giddiness and drowsiness. Aflatoxicosis, which is caused by consumption of foodstuffs contaminated with aflatoxins, was reported in 1974 among tribals in Western India and more recently in 2004 in Kenya. The characteristic features of aflatoxicosis were jaundice, rapidly developing ascites and portal hypertension. In 1987, a considerable segment of the population of the Kashmir valley was affected by a gastrointestinal disorder symptomised by abdominal pain and vomiting. The outbreak was associated with the consumption of bread made from mould-damaged wheat and the presence of varying quantities of *trichothecene* mainly *deoxynivalenol.*

Bacteria, you may recall reading in Unit 5, also produce toxins which result in food poisoning. Important bacterial agents implicated in poisoning outbreaks in India are *Staphylococcus aureus, Salmonella* and *Bacillus cereus.* Bacterial food poisoning is perhaps the most common adverse health effect of consuming contaminated food. Prominent symptoms include vomiting, diarrhoea and in some cases fever.

6.4.2 Pesticide Residues

Codex Alimentarius defines pesticides as *any substance intended for preventing, destroying, attracting, repelling or controlling any pest including unwanted species of plants or animals, during production, storage, transport, distribution and processing of food agricultural commodities, or animal feeds or which may be administered to animals for the control of ectoparasites* (parasites that live on but not within their hosts). It includes substances intended for use as a plant growth regulator, defoliant, desiccant, fruit thinning agent or sprouting inhibitor and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport. It normally excludes chemicals such as fertilizers, plant and animal nutrients, animal drugs and food additives.

Pesticides are used to protect food from pests, such as insects, rodents, nematodes, fungi, moulds, and bacteria. Pesticides used on food include:

- insecticides to prevent, destroy, kill or mitigate insects
- rodenticides to inhibit growth, destroy or kill rodents
- herbicides to prevent or inhibit the growth of weeds
- fungicides to prevent, destroy or inhibit the growth of mould and fungus
- nematicides to prevent, destroy, repel or inhibit the nematodes, and
- antimicrobials to control bacteria.

Pesticides can also be classified based on their nature as:

- organochlorine pesticides
- organophosphates and carbamates, and
- pyrethrins and pyrethroids

In addition, a large number of inorganic pesticides are also in use.

The use of pesticides has increased several-fold in India and it is likely to increase in the forthcoming years. A significant amount of the pesticides used in agriculture, leach into the rivers (especially from farms bordering river banks) and other water bodies. It is a well-known fact that indiscriminate use of pesticides has also lead to

high residue levels in food. Even small quantities of these residues present in food lead to high levels in the body fat when these food stuffs are consumed over long periods of time. The effects of pesticide consumption are many. They vary from minor health problems like skin and other allergic reactions to carcinogenicity. The long term effects could also be reduction of life span and fertility in addition to several metabolic and genetic disorders.

After pesticides are sprayed, they slowly start dissipating. Every pesticide has some *safety* or *waiting period* which is defined as the '*number of days to lapse before the pesticide residues get dissipated*'. Pesticide residues are defined as *any specified substance in food, agricultural commodities, or animal feed resulting from the use of a pesticide.* It includes any derivatives of a pesticide, such as conversion products, metabolites, reaction products and impurities considered to be of toxicological significance. It differs from pesticide to pesticide and also from one crop to the other. Food products become safe for consumption only after the waiting period has lapsed. If fruits and vegetables are harvested before completion of the waiting period, it is likely to have higher level of residues which are hazardous to health.

Residues of pesticides have been found in almost all kinds of foods viz. milk and milk products, edible oils and fats, food grains, vegetables and fruits. A recent study estimated that between 50 and 70 per cent of all vegetables grown and sold around the country were contaminated with pesticide residues, some of them well beyond the permissible levels. In fact, our own bodies at present may contain at least one pesticide in detectable amounts. Studies in India have shown the presence of pesticides like DDT and BHC in the breast milk of some women.

Pesticide residues cause acute and long term toxic effects in human beings, animals, fish and birds. During spraying operations, they affect the point of contact such as skin and eyes. Pesticides also affect the internal organs of the body after they are absorbed. Continued exposure for long periods causes liver or kidney problems and also affects the nervous system. It can also cause mutation resulting in birth defects. *Lindane* is one of the most harmful *organochlorines*. If consumed over a period of time, it affects the central nervous system, liver, kidney, pancreas, testes and nasal mucous membrane. Lindane poisoning symptoms include headache, dizziness, gastrointestinal disturbances, numbness and weakness of the extremities, apprehension and hyperirritability. Assessing the impacts of pesticides, especially organochlorines on fish and wildlife, is becoming increasingly important because of the recent evidence suggesting that some organochlorines, even at low concentrations, disrupt the endocrine system, which is responsible for proper hormone balance.

Food poisoning outbreaks due to pesticides being mixed with food inadvertently have been described. In one instance, people who ate at a community lunch developed symptoms of nausea, vomiting and abdominal pain. On investigation it was discovered that the pesticide *'malathion'* had been sprayed in the kitchen where the raw ingredients had been kept for cooking the lunch. Accidental spillage of pesticide on *jowar* in another case, resulted in abdominal pain, vomiting and loose motions in people who consumed *rotis* made from it. In another outbreak, several lives were lost when villagers consumed food grains which had been mixed with the *pesticide BHC* for storage and preservation purposes.

In recent times, there are several measures being taken to regulate the contamination of food with pesticide residues to safe levels. In fact, the *Prevention of Food and Adulteration Act, 1954* of India has prescribed limits of tolerance for pesticide/insecticide residues in food and food commodities for a selected number of pesticides. This is presented in Annexure 1, Table I.

Check Your Progress Exercise 3

1) Enumerate the environmental contaminants. How do they enter the food chain?

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2) How do biological contaminants lead to food borne illness?

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3) Define Pesticide residue. What are the different pesticides that are used on our foods?

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4) Define the following terms:

a) Waiting period

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b) Mycotoxin

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The next environmental contaminant we are going to study about are the veterinary drug residues.

6.4.3 Veterinary Drug Residues

The advancements in animal husbandry and the field of medicine have resulted in the ever expanding use of drugs. These drugs are used to improve or maintain the health of an animal species regardless of whether these are intended for food products or otherwise. A significant number of these chemicals ultimately in one way or another, end up in our food (as residues in meat or milk) and water supply. The milk and flesh of animals fed antibiotics and other growth stimulating medicines and hormones becomes contaminated with the residues of these drugs. Usually these drugs remain in the body of the animal for a few days and the animal should not be milked or killed for meat during that period after the administration of the drug. Ignorance and non -compliance with safety norms can however lead to these compounds entering our food.

Of the different types of veterinary drugs used in food producing animals, *veterinary drug residues, especially antibiotic residues and steroid hormones*, are of concern because of their possible adverse effects on persons allergic to certain antibiotics like penicillin and the potential build up of antibiotic resistant organisms in humans. When the microorganisms present in our intestines are exposed to low doses of antibiotics

in the form of residues in the food that we eat (viz. meat, milk and eggs of contaminated animals), they start becoming resistant to the drug. Acute poisoning outbreaks attributed to veterinary drugs have also been described in literature. Some people in Lyons, France developed symptoms of tremor, headaches, abnormally rapid heart rate and dizziness 1 to 3 hours after eating veal liver. On investigation this was revealed to be a case of poisoning by *clenbuterol residues* in the veal liver.

In addition, antibiotic residues present in milk, intended for the production of cheese or for the formation of milk products requiring the use of bacterial or yeast cultures, may result in killing of these cultures. This results in subsequent economic losses to the dairy industry. Use of steroid hormone-*diethylstibesterol*, in beef production has now been banned due to indications that it is a carcinogen. Another important hormone that is naturally present in animals and is used to the stimulation of growth and lactation in farm animals is *bovine somatotropin* (BST). It is legally permitted to be used in India as no residues in animal products are likely to occur. The salient veterinary drug residues and their maximum residue limits (MRL) for different food commodities, as given by Codex. Alimentarius is given in Annexure 1, Table II.

6.4.4 Heavy Metals

Like the foods we consume, our bodies also contain many metallic elements. Most of these metals are actually required for the normal functioning of our bodies. Some of these metals, especially the heavy metals are toxic. Heavy metals like mercury, cadmium, nickel, arsenic, lead and aluminium are used by several industries. These contaminate our foods when factories throw their waste products into the seas and rivers or bury their wastes before appropriately treating them. Smoke from industries, as well as, exhaust fumes from vehicles and machinery pollute the atmosphere. Thus heavy metals enter our bodies via the water we drink, the air we breathe and the food that is grown in such contaminated soil.

Metals may also enter food from metallic cans in which the food is packaged. Acidic conditions in the stored products may cause the surface layer of the cans to dissolve into the food products. Aluminium containers which can also be slowly dissolved under acidic conditions are more rapidly corroded under more alkaline conditions. Another source of chemical contaminants is vessels and utensils used in cooking and storage of prepared foods and beverages. Vessels made of brass are usually tinned from inside. Poor quality tin coating or improper tinning of the vessels can result in tin and copper leaching into the food cooked or stored in the vessel.

Heavy metals pose a substantial risk to human health. These metals are not readily excreted from our bodies and can accumulate to toxic levels over a period of time. The vegetable crop has been found to suck in heavy metal and other contaminants from soil, water and air. Fields on the fringes of urban areas, supplying cities, are the worst affected. Raw sewage water and sludge used for irrigation in some parts of the country have led to a build-up of heavy metals up to 30 cm in the soil. Recently, an article in the newspaper reporting high levels of heavy metals tested in vegetables, particularly the green leafy vegetables, grown in areas in and around Delhi, is testimony to this problem.

Let us examine these metals, which can be of concern, in greater details.

Arsenic

Arsenic is usually classified as a *metalloid*, since it has properties both of a metal and a non-metal. It is present in small quantities in most human foods. In parts of West Bengal, soil and crops show arsenic build-up after being irrigated with arsenic -rich water. It is introduced into water through the dissolution of minerals and ores and also from erosion from local rocks. Industrial effluents also contribute arsenic to water in some areas. In fact, contamination of drinking water with arsenic is a major problem in the area, as it poses serious health concerns. Absorption of arsenic through the skin is minimal and thus hand-washing, bathing, laundry etc. with water

containing arsenic does not pose human health risk. Symptoms of chronic arsenic poisoning include general muscular weakness, loss of appetite, nausea and inflammation of the mucous membrane of the eyes, nose and lungs. The most characteristic effects following chronic arsenic exposure are hyperkeratosis (thickening of the skin) seen in the palms and soles of the feet together with hyperpigmentation, as highlighted in the Figure 6.7, particularly in areas not exposed to the sun. While immediate symptoms of an acute poisoning typically include vomiting, oesophageal abdominal pain and bloody 'rice water' diarrhoea.

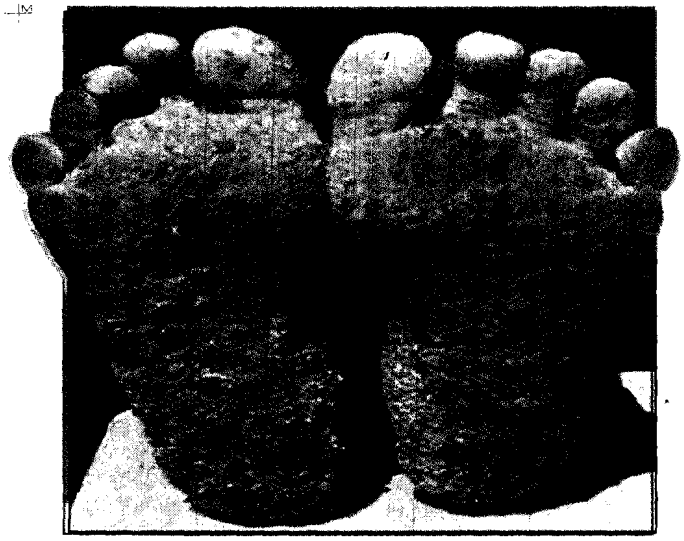

Figure 6.7: Arsenic poisoning

Lead

Lead, even at relatively low levels of exposure can cause severe health effects. Exhaust from vehicles using unleaded petrol serves as an important source of lead in the atmosphere. Lead may also be present in industrial wastes, paints, ceramic glazes, cosmetics and ultimately may pollute not only the air we breathe but also the soil and water. Several surveys have detected high levels of lead in different foodstuffs, drinking water and seafoods like shrimps. It affects the human nervous system, production of blood cells, kidney, reproductive system and behaviour. It increases the risk for premature birth and can induce miscarriage. The main effects of chronic lead poisoning are seen on the blood cells, nervous, gastrointestinal, reproductive and renal systems. Some of the symptoms of acute poisoning, which occurs on consuming single large doses of the toxin are tiredness, abdominal discomfort, irritability and anaemia.

Mercury

While this metal is a naturally occurring element, coal-fired power plants and other industrial processes pump extra tonnes of this contaminant into the environment. Among the various foods, it is seafood, which has been found to be the most commonly contaminated with mercury. Much of this mercury ends up in water and subsequently in the tissues of fish. The source of mercury poisoning is primarily contamination of food from polluted water containing mercuric compounds from industrial waste or organic mercury contained in some fungicides. Food or feed grains treated with mercury containing fungicides are yet another potential source for transmission of the metal through both animal and cereal foods. Mercury is one of the most toxic of heavy metals, in fact it is *a neurotoxin*. In Japan, the *Mina-mata* disease was attributed to mercury poisoning. The people affected experienced loss of appetite, spastic paralysis, weight loss, tiredness, impaired vision and finally developed kidney failure. In high doses, it can cause neurological problems such as speech and hearing impairment, loss of coordination and a tingling sensation in the

limbs. What is most alarming is the fact that mercury can easily pass through the placenta and harms the foetus during pregnancy.

Cadmium

An increase in the soil cadmium content due to soil pollution by industrial wastes, burning of coal, fossil fuels, sewage sludge, medical and municipal waste results in an increase in the uptake of cadmium by plants. High levels of cadmium have also been detected in seafood like shrimps. The cadmium absorbed by our bodies is retained for several years. This is, in fact, a problem with all heavy metals. Our body is not able to effectively throw out these metals. Cadmium is a highly toxic metal. One example of cadmium toxicity was highlighted by *Itai Itai* (bone damage) disease in Japan in 1960. Chronic exposure to this metal causes renal damage, heart disease, anaemia, skeletal weakening and depressed immune system response.

Aluminium

Most natural foods have relatively low levels of aluminium. Aluminium in foods includes what is present naturally plus that coming from certain food additives, food containers and cooking utensils. Besides these, exposure to aluminium may also occur through the use of some products for treating diarrhoea, haemorrhoid medications, antiperspirants and lipsticks. This metal has been implicated in *Alzheimer's disease*, a chronic progressive disease characterized by a gradual loss of cognitive functions. The role of aluminium in a variety of bone diseases is also well recognized.

Antimony

Antimony enters the air, soil and water as a by-product from the smelting of lead and other metals. The symptoms of antimony poisoning are coronary and pulmonary problems, stomach pain, diarrhoea, vomiting and stomach ulcers. It plays a role in *Sudden Infant Death Syndrome (SIDS)*.

Chromium

It often accumulates in aquatic life, adding to the danger of eating fish that may be exposed to high levels of chromium. Low level exposure can irritate the skin and cause ulceration. The long-term exposure can lead to, kidney and liver damage, as well as, damage to circulatory and nerve tissue.

Copper

Copper, as you may already know, is an essential micronutrient to human life. It normally occurs in drinking water from copper pipes. When consumed in high dosage, it can cause anaemia, liver and kidney damage, and stomach and intestinal irritation. People with *Wilson's disease* are at a greater risk for health effects from overexposure to copper.

Nickel

It occurs naturally in some foods and manufacturers use it in the hydrogenation process. Nickel exposure also occurs from both first and second-hand tobacco smoke. It accumulates in aquatic food chains with freshwater organisms being more sensitive than the ones from salt water.

Tin

Canned foods contain higher levels of tin because the tin coating used to protect the steel body of the can from corrosion can slowly transfer tin into food. Though no long-term health effects are associated with consuming tin but it can cause symptoms such as stomach upsets, nausea, vomiting, diarrhoea, abdominal cramps and bloating.

In the sections above, some examples of acute poisoning outbreaks due to the consumption of contaminants have been discussed. Unfortunately, the appearance of

the toxic effects of chemical contaminants may not always be immediate. It may be delayed in view of the small quantities ingested over a period of time. Thus, the cause and effect relationship between ingestion of the contaminant and toxic effect seen at a later date cannot easily be demonstrated. This is further complicated by the multiplicity of chemical contaminants that may be ingested at any given time. Ingestion of chemical contaminants can be greatly reduced by following good agricultural practices: minimizing the use of pesticides, chemical fertilizers, following good practices of animal husbandry especially when the animals need medication and ensuring safe disposal of toxic wastes from our industries. At the household level, we can do simple things like washing thoroughly the grains, fruits and vegetables before consuming them. Removing the peels of fruits and vegetables also helps in removing contaminants adhering to the skin. Fruits and vegetables growing in the vicinity of polluting industries should be avoided. While consuming non-vegetarian foods, organ meats (viz. kidney, liver, brain) should be avoided as they tend to accumulate heavy metals. Fish from deep sea and lakes or free-flowing rivers are safer than those caught in water bodies close to industries releasing effluents or sewage treatment plants.

For your information the tolerance limits of poisonous metals in various items of food as prescribed under PFA rules is given in Annexure 1, Table III.

Check Your Progress Exercise 4

1) What are veterinary drug residues and how do they enter our food chain?

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2) How do veterinary drugs pose a threat to us?

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3) List the ways in which toxic heavy metals enter our food chain.

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4) Suggest measures to reduce our exposure to chemical contaminants.

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Finally, in our study of food contaminants, we shall learn about the miscellaneous contaminants, which are basically the toxic chemicals present in our food as contaminants.

6.5 MISCELLANEOUS CONTAMINANTS

A host of other toxic chemicals can be present in our foods as contaminants. As the list is endless, we will be discussing only some of them in this section. Contaminants derived during storage from packaging and canning materials in contact with the foodstuffs are of great concern to us. Such contaminants leach out of packaging materials into the food products. Let us learn more about some of these contaminants.

Dioxins are a group of chemicals (polychlorinated aromatic compounds) with similar structures, chemical and physical properties. You may recall reading about them in Unit 2 earlier in section 2.5 under the heading. 'Recent Concerns of Food Safety'. Dioxins, are not produced intentionally or deliberately, but are formed as a by-product of chemical processes. These range from natural events such as volcano eruptions and forest fires to manmade processes, such as manufacturing of chemicals, pesticides, steel and paints, pulp and paper bleaching, exhaust emissions and incineration. For example, when chlorinated waste is burned in an uncontrolled way in an incinerator, the emissions to the air contain dioxins.

Dioxins are not soluble in water and are highly soluble in fat. This means that they bind to sediment and organic matter in the environment and are absorbed in animal and human fatty tissue. In addition, they are not biodegradable, so they are persistent and accumulate in the food chain. This means that once released into the environment, via air or water, they pile up in the fat tissue of animals and humans. Human exposure to dioxins can occur through working in industries where dioxin is a by-product, industrial accidents, food, human breast milk and drinking water. Dioxins can enter the food supply through a number of different routes. Soil is a natural sink for dioxins. Apart from atmospheric deposition, soils may be polluted by sewage sludge or composts, spills and erosions from nearby contaminated areas.

Dioxins have a broad series of toxicological and biochemical effects and some of them are classified as known human carcinogens. In laboratory animals, they have been linked to severe effects on the uterus, developmental effects and learning disabilities, developmental reproductive effects (low sperm count, genital malformations) and immunotoxic effects. These effects occur at much lower levels of exposure than carcinogenic effects.

PCBs or polychlorinated biphenyls are another group of chemicals. They are chlorinated aromatic hydrocarbons. PCB mixtures are still widespread and present today, such as in transformers, building materials, lubricants, coatings, plasticizers and inks. Some of the PCB compounds have toxicological properties that are similar to dioxins and are therefore often termed "dioxin-like" PCBs. Although the production and use of most PCBs has been discontinued in almost all industrial countries, as a result of their widespread use in the past, large amounts of PCBs remain present until today in electrical equipments, plastic products, buildings and in the environment. As a result, PCBs are also still ending up in waste streams.

Aerial transport and deposition of dioxins and dioxin-like PCBs are also the main sources of contamination of leafy vegetables, pastures and roughages. Dioxins and dioxin-like PCBs are poorly soluble in water, but are adsorbed onto mineral or organic particles in suspension in water and thus enter the aquatic food chain. In general, food of animal origin contributes to about 80% of the overall human exposure. Animal fat acts as a sponge for PCB and hence they are found in foods containing animal fat like meat, fish, eggs and milk.

High levels of PCB in the blood have been linked to reduced cognitive skills, mental development and suppressed immune reactions, especially in children exposed to PCB in the womb. The first evidence of mass poisoning by PCB came to light in 1968 in Yusho, Japan. The heat degraded products of this chemical used in the heat exchangers for decolourization of rice bran oil, contaminated the oil. The number of still-births in women who consumed this oil increased, as did the number of children born with varied health problems. Recent studies suggest that PCB can also cause short-term memory and learning problems in adults.

Acrylamide is a chemical that appears to be produced naturally in food as a result of baking or frying. It is also likely to be produced by grilling and roasting food. In industry, it is manufactured as a crystalline white powder and is used in the production of polyacrylamide. This is used as an additive for water treatment.

On the basis of animal data and understanding of its biological effects, acrylamide is considered to be a probable human carcinogen. It has caused nerve damage in people who have been exposed to it at work. In studies on male animals, acrylamide was shown to impair fertility. As acrylamide has very recently been discovered in food such as potato at such high levels so as to cause concern, practically nothing is known about its effects on humans via the diet.

The next most important contaminant which is of concern today in the modern world, is the use of plastic. Let us get to know how contaminants from plastic enter the food.

Contaminants from plastics

Plastics are widely used in contact with foodstuffs, namely, in food processing equipment, food utensils and as food packaging. In their manufacture, numerous additives are used depending on the type of produced polymer. These additives include plasticizers, antioxidants, catalysts, suspension and emulsifying agents, stabilizers and polymerization inhibitors, pigments, fillers etc. These additives are bound either chemically or physically into the polymer and may be present in their original or an altered form. In addition, the polymerization process may leave trace quantities of residual monomer or low-molecular-mass polymer in the plastic. These substances can be of concern if present in amounts more than specified. It is, therefore, necessary to specify the purity of the polymer to be used in the preparation of plastic intended for food and/or drinking water. This is exactly what is meant by the term "*food grade plastic*" – which we often see on the plastic containers, packaging materials or utensils.

The extent to which the migration of contaminants into foods occur, will depend upon factors such as the contact area, the rate of transfer, the type of plastic material, the temperature and the contact time. The migration of substances from plastic into food is also related to the type of food packaged. Alcoholic beverages and edible fats and oils will extract substances more readily than dry food such as cereals.

The high-molecular-mass polymer in plastics itself does not pose a toxic hazard, being inert and essentially insoluble in food. Monomers which make up the polymer are very reactive and biologically aggressive. Some of them have been shown to cause allergic effects, to damage the liver and reproductive functions and to cause cancer.

Plasticizers are used to assist processing and impart flexibility to plastics. They can be present in food packaging materials in significant amounts and have the potential to migrate into food. The migration of plasticizers can be aggravated by heat and by the presence of a food into which the plasticizing chemical will dissolve (for example, oil, acid or alcohol). We will learn more about contamination from plastics in Unit 11, under section 11.6

Check Your Progress Exercise 5

1) Why should only food grade plastic materials be used for packaging and storing foodstuffs?

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2) How do dioxins enter our food supply?

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3) What is acrylamide? Is it harmful? Why?

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4) What are the harmful effects of PCB? What foods are they more likely to be present in?

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6.6 LET US SUM UP

The maintenance of good health demands that the food we consume should not only be nutritious but also safe and of good quality. There has been a growing concern regarding the environmental contamination of food in the country in recent times. This unit focussed on this aspect.

Further, we learnt that naturally occurring toxicants in some plant and animal foods pose a health hazard. Shellfish toxins, toxic amino acids, alkaloids and cyanogenic glycosides are some of the toxicants that can have very serious and sometimes fatal consequences. Anti-nutritional substances like tannins, phytates, oxalates, enzyme inhibitors, goitrogens etc. interferes with the assimilation of nutrients by our bodies. Hence, it is very important to create public awareness about the different kinds of food toxicants that can be present in our foods and how the common man can reduce his exposure to these toxicants.

Biological and chemical contaminants also make our food unsafe to eat. Bacteria, fungi and their toxic metabolites constitute biological contaminants. The list of chemical contaminants is long and varied. Going through the unit, you may have realized that as a part of modern advances in agricultural technology, the application of pesticides and fertilizers to crops and the use of various compounds in animal husbandry and veterinary practice have increased, often resulting in residues of these unintended contaminants persisting in the final food product. In addition, contaminants like heavy metals, dioxins, PCB, plasticizers and other chemicals from the packaging materials may leach into the food. This unit, therefore, focussed on the fact that these contaminants can have serious health consequences, most of them being implicated as carcinogenic or cancer-causing. It is, hence, vital for us to adopt appropriate measures to reduce our exposure to these chemicals.

6.7 GLOSSARY

Apathy	:	lack of interest or feeling, indifference.
Ataxia	:	defective muscular co-ordination, especially during voluntary muscular movement.
Biogenic	:	produced by living organisms.
Dyspnea	:	difficult or laboured breathing.
Dysuria	:	painful or difficult urination.

Edema	:	swelling due to watery fluid collecting in the cavities or tissues of the body.
Erythema	:	a superficial reddening of the skin, usually in patches.
Hyperkeratosis	:	overgrowth of the horny layer of the epidermis.
Hyperpigmentation	:	increased pigmentation of the skin.
Morbidity	:	sickness, indicative of disease.
Mortality	:	of, or relating to death.
Mutation	:	a change in the chemical constitution of the DNA in the chromosomes of an organism.
Myalgia	:	tenderness or pain in the muscles.
Paresthesias	:	sensation of numbness, prickling or tingling.
Perioral	:	surrounding the mouth.
Plankton	:	microscopic organisms drifting or floating in the sea or fresh water.
Portal hypertension	:	increased pressure in the portal vein as a result of obstruction of the flow of blood through the liver.
Vertigo	:	dizziness, giddiness.
Veterinary	:	pertaining to animals, their diseases and treatment.
Wheezing	:	breathing with an audible whistling sound.
Winnowing	:	blowing (grain) free of undesirable foreign particles, husk etc. by an air current.

6.8 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) Any substance not intentionally added to food, which is present in such food as a result of the production (including operations carried out in crop husbandry, animal husbandry and veterinary, medicine), manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food as a result of environmental contamination is referred to as food contamination.

   The three main types of contaminants in foodstuffs are biological, physical and chemical contaminants.

2) Naturally occurring toxicants are the products of the metabolic processes of animals, plants and microorganisms from which food products are derived. Many of these substances in food products are potent poisons.

3) The different types of shellfish poisoning are paralytic shellfish poisoning caused by saxitoxin; pufferfish (*Tetrodon*) poisoning caused by Tetrodotoxin, ciguatera toxin poisoning, scombroid poisoning.

4) a) Ciguatera poisoning leads to abdominal cramps, nausea, vomiting, profuse watery diarrhoea, myalgias, arthralgias, weakness, and dysuria. Neurologic symptoms tend to occur later (up to 72 h) and may persist for months. These are predominantly paresthesias, but a myriad of other sometimes bizarre neurologic symptoms also may be observed, including sensation of loose painful teeth, tingling in the lips, tongue and throat, vertigo, ataxia, visual changes and seizures. Death is rare.

b) The symptoms of scombroid poisoning are skin flushing, facial swelling, dizziness, throbbing headache, oral burning, metallic, sharp or peppery taste in mouth, abdominal cramps, nausea, vomiting, diarrhoea, palpitations, a sense of unease, and, rarely, prostration or loss of vision characterize scombroid. A rash that looks like sunburn may occur and a small number of patients have hives, i.e., allergic skin reaction. Physical signs may include a diffuse erythema (a reddening of the skin due to capillary dilation), tachycardia, wheezing, and hypotension or hypertension.

Check Your Progress Exercise 2

1) The toxicants which have been identified in foods for human consumption are toxic amino acids such as beta-oxalyl aminoalanine, toxic alkaloids such as sanguinarine, cyanogenic glycosides and mushroom poisoning.

2) Mushroom poisoning is caused by the consumption of raw or cooked fruiting bodies (mushrooms, toadstools) of a number of species of higher fungi. The toxins involved in mushroom poisoning are produced naturally by the fungi themselves. Most mushrooms that cause human poisoning cannot be made non toxic by cooking, canning, freezing, or any other means of processing. The only way to avoid poisoning is to avoid consumption of the toxic species.

3) Anti-nutritional compounds are the substances present in foods, particularly those of plant origin, which interfere with the assimilation of nutrients by our body. Some of the important anti-nutritional factors are trypsin inhibitors, phytates, oxalates, tannins, lectins and goitrogens.

4) i) - e)

ii) - d)

iii) - b)

iv) - c)

v) - a)

5) i) - c)

ii) - a)

iii) - d)

iv) - b)

Check Your Progress Exercise 3

1) The environmental contaminants are industrial effluents, untreated sewage and household chemical wastes (detergents, soaps, pesticides, discarded batteries, etc.) and residues of pesticides, fertilizers and veterinary drugs used in agriculture and animal husbandry. They enter by food chain by soil, water and air. These toxic chemicals present in the soil, water and air are taken in by the plants and by land and marine animals. Indirect contamination of meats, milk or eggs may occur as a result of ingestion of contaminated plants by animals.

2) The biological contaminants, that is, the microorganisms present in the soil, water and air may infect the growing plant and stored foodstuffs and produce harmful metabolites. Warm temperatures and high moisture content serve as ideal conditions for the growth of microorganisms like bacteria and fungi in stored food products. These types of contaminated foodstuffs have been the cause of many serious poisonings in man and animals which have even resulted in death.

3) Pesticide residue is any specified substance in food, agricultural commodities or animal feed resulting from the use of a pesticide. It includes any derivatives of a pesticide, such as conversion products, metabolites, reaction products and impurities considered to be of toxicological significance. The different pesticides that are used on our foods are insecticides, rodenticides, herbicides, fungicides, nematicides and antimicrobials.

4) a) Waiting period is the number of days to lapse before the pesticide residues get dissipated

b) Toxins produced by fungi are referred to as mycotoxins.

Check Your Progress Exercise 4

1) Veterinary drug residues are used to improve or maintain the health of an animal species regardless of whether these are intended for food products or otherwise. A significant number of these chemicals ultimately in one way or another, end up in our food (as residues in meat or milk) and water supply.

2) Veterinary drugs pose a threat to us because of their possible adverse effects on persons allergic to certain antibiotics like penicillin and the potential build up of antibiotic resistant organisms in humans. When the microorganisms present in our intestines are exposed to low doses of antibiotics in the form of residues in the food that we eat (viz. meat, milk and eggs of contaminated animals), they start becoming resistant to the drug.

3) Toxic metals can enter our food chain in the following ways:

- industrial wastes being thrown into the seas and rivers pollute our drinking water and the fish that we eat,
- burial of untreated industrial waste pollute the soil in which our food crops are grown,
- exhaust from vehicles using unleaded petrol contaminate the air with lead which might also settle on exposed foodstuffs or be taken in by the animals which supply us meat, and
- leach into our food from cans and vessels used for packing, cooking or storing the food.

4) Ingestion of chemical contaminants can be greatly reduced by following good agricultural practices: minimizing the use of pesticides, chemical fertilizers, following good practices of animal husbandry especially when the animals need medication and ensuring safe disposal of toxic wastes from our industries. At the household level: washing thoroughly the grains, fruits and vegetables before consuming them, removing the peels of fruits and vegetables helps in removing contaminants adhering to the skin, avoiding fruits and vegetables grown in the vicinity of polluting industries, avoid eating organ meats and fish from water bodies close to industries releasing effluents or sewage treatment plants.

Check Your Progress Exercise 5

1) Food grade plastic materials should be used for packaging and storing the food to ensure the purity of the polymer to be used in the preparation of plastic intended for food and/or drinking water so that there is a minimum migration of toxic chemicals in food stuffs.

2) Human exposure to dioxins can occur through working in industries where dioxin is a by-product, industrial accidents, through food, human breast milk and drinking water. Dioxin can enter the food supply through atmospheric deposition, soils may be polluted by sewage sludge or composts, spills and erosion from nearby contaminated areas.

3) Acrylamide is a chemical that appears to be produced naturally in food, as a result of baking or frying. It is also likely to be produced by grilling and roasting food. Yes it is harmful, as it is considered to be a probable human carcinogen.

4) High levels of PCB in the blood have been linked to reduced cognitive skills, mental development and suppressed immune reactions, especially in children exposed to PCB in the womb. Recent studies suggest that PCB can also cause short-term memory and learning problems in adults. They are found in higher concentrations in foods containing animal fat like meat, fish, eggs and milk.