Pollution and Vegetable Contamination: A Review of the Impact of Various Pollutants

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Abstract— Environmental pollution nowadays is a big concern. Anthropogenic activities have altered the environment significantly throughout the world like mining, industry and agriculture. This causes an increase in the Lead (Pb), Cadmium (Cd), Arsenic (As) content of soil and water, thus contaminating them. The increased uptake of these metals by plants influences the natural contents of vegetables and thus poses serious health impacts. Air pollutants like sulphur dioxide, ozone and peroxyacetyl nitrate also cause significant injury to plants and vegetables depending on the concentration and duration of exposure. In this paper, we present a review of the influence of these pollutants on vegetable content and hence their impact on human health.

Keywords: Pollutants, Contaminated Vegetables, Lead, Cadmium, Ozone, Sulphur Dioxide, Arsenic

I. INTRODUCTION

Vegetables are an important ingredient of human diet that contains essential nutrients and trace elements [1]. Pollution of the environment causes contamination of soil. Waste water irrigation leads to mixing of heavy metal content in the agricultural land. The heavy metals are leached out of soil and are taken up by the vegetation. This leads to contamination of vegetables which causes numerous harmful health impacts. When these plants decay, these toxic metals are redistributed and this results in their enrichment in the agricultural soil [2]. Thus long term waste irrigation leads to build up of heavy metals in soil and hence food crops [3]. Anthropogenic activities, such as agriculture, industry and urban life increase the Pb, Cd and As contents of soils and waters and, therefore, have an effect on the metal contents of vegetables [4]. Vegetables absorb heavy metals from the soil as well as from surface deposits on the parts of vegetables exposed to polluted air [5]. Moreover, the presence of heavy metals in fertilizers contributes an additional source of metal pollution for vegetables [6].

A major pathway of soil contamination is through atmospheric deposition of heavy metals from point sources, such as metalliferous mining, smelting and industrial activities. Other non point sources of contamination affecting predominately agricultural soils are due to various inputs, such as fertilizers, pesticides, sewage sludge, organic manure and compost [7]. Additionally, foliar uptake of atmospheric heavy metals from emission gas has also been identified as an important pathway of heavy metal contamination in vegetable crops [8].

The burning of coal and other fossil fuels gives rise to various chemical pollutants such as SO_2 (sulphur dioxide), NO_x (nitrogen oxides such as nitrite, nitrate, etc.), O_3 (ozone) as well as a variety of other hydrocarbons. Ozone and peroxyacetyl nitrate (PAN) produced in these reactions can become injurious to plants depending on concentration and duration of exposure. Plant injury caused by air pollution is most common near large cities, smelters, refineries, electric power plants, airports, highways, incinerators, refuse dumps, pulp and paper mills, and coal-, gas-, or petroleum-burning furnaces. Factors that govern the extent of damage and the region where air pollution is a problem are (1) type and concentration of pollutants, (2) distance from the source, (3) length of exposure, and (4) meteorological conditions. Accumulation of toxic substances by plants may depend on plant species, soil properties and various other factors. The uptake and accumulation of these toxic substances in human body created growing concern in the recent days [9]. In this context, this paper explains the impact of various pollutants on vegetables.

II. METHODOLOGY

A. Impact of Different Pollutants

1) Sulphur Dioxide (SO_2)

Sulphur dioxide is a major component in acid rain. It is the most important and common air pollutant produced in huge amounts in combustion of coal and other fuels in industrial and domestic use. It is also produced during smelting of sulphide ores. One of the byproducts of sulfur dioxide is sulfuric acid, and both can be extremely damaging to plants that are exposed to these chemicals [10]. Exposed leaves can begin to lose their color in irregular, blotchy white spots. Some leaves can develop red, brown or black spots. When the pigments in enough tissue are damaged or killed, plants can begin to lose their leaves. Crop output is greatly reduced and growth can be stunted. This is especially noticeable in young plants. SO_2 contaminated vegetables produce adverse health effects. The symptoms of irritation are constriction of the air pathways (respiratory tract) with corresponding increases in resistance to air flow during breathing. SO_2 is deemed by public health authorities to be a serious pollutant. The reason for such concern is the way it affects aged population, particularly those who suffer from diseases of the respiratory and cardiovascular systems. These aged people are highly susceptible to prolonged exposure to SO_2.

2) Ozone and Peroxyacetyl Nitrate (PAN)

Ozone (O3) is probably the most important plant-toxic air pollutant. It is a very active form of oxygen that causes a variety of symptoms on broad-leaved plants: tissue collapse, interveinal necrosis, and markings on the upper surface of leaves, flecking and necrosis. Ozone stunts plant growth and depresses flowering and bud formation.

PAN causes a collapse of tissue on the lower leaf surface of most plants resulting in leaves that develop bands or blotches of glazed, bronzed or silvery areas [11]. The affected leaves usually senesce prematurely. On some plants, such as Pinto bean, tomato, and tobacco, the injury can occur through the entire width of the leaf blade. PAN is most toxic to small plants and younger leaves, but leaves just forming

and starting to open and the most mature leaves are less susceptible to PAN injury.

Both ozone and PAN are products of photochemical smog. They cause irritation of the eyes and respiratory tracts of human beings. Exposure to 50 ppm of O_3 for several hours will lead to mortality due to pulmonary edema, i.e. accumulation of fluid in the lungs. At lower levels, O_3 nonlethal accumulation of fluid in the lungs and damage to lung capillaries. Young animal and humans are more susceptible to these toxic effects than older subjects.

3) Lead (Pb)

Lead is available to plants from soil and aerosol sources. The extent to which Pb enters plants via the leaves depends on the ability to absorb Pb from aerial sources which in turn depends on the roots [12]. Excessive lead accumulation in plant tissue impairs various morphological, physiological, and biochemical functions in plants, either directly or indirectly, and induces a range of deleterious effects. The negative effects that lead has on plant vegetative growth mainly result from the following factors: distortion of chloroplast ultrastructure, obstructed electron transport, inhibition of Calvin cycle enzymes, impaired uptake of essential elements, such as Mg and Fe, and induced deficiency of CO_2 resulting from stomatal closure. Leafy vegetables, potatoes and beans are likely to absorb more lead than fruiting crops like tomatoes etc.

Lead obstructs the utilization of oxygen and glucose for the life sustaining energy production. The interference with normal metabolic functions starts when the blood-lead level reaches .3 ppm. When the blood-lead level reaches about .8 ppm, symptoms of anemia will be observed due to deficiency of haemoglobin. Higher levels of lead in the blood can cause kidney dysfunction and brain damage because it is toxic to the central and peripheral nervous system.

4) Arsenic (As)

Arsenic pollution occurs mainly from its release into air from smelting of As-containing ores, burning of coal and use of arsenic compounds in various applications such as fungicides, insecticides, herbicides, pesticides and preservatives. Arsenic released from natural agencies such as weathering processes on a global scale is estimated to be about $8*10^4$ metric tonnes per year while man-made activities account for about $24*10^4$ metric tonnes per year.

Arsenic is a general protoplasmic poison and it affects all systems in the body. It is a cumulative poison. The major biochemical effects of arsenic are: (i) complexation of coenzymes (ii) uncoupling of phosphorylation and (iii) coagulation of proteins. Chronic ingestion of inorganic arsenic causes peripheral arteriosclerosis, commonly known as 'black foot disease'. It may also cause peripheral neuritis resulting in motor and sensory paralysis of the nerve extremities. Arsenic is toxic to liver and it produces fatty infiltration and causes central necrosis and cirrhosis. Arsenic poisoning also affects bone marrow and cellular elements of blood. Arsenicals are known to be carcinogenic to lungs. They may also lead to skin cancer through the initial skin lesions.

5) Cadmium (Cd)

Cadmium is a toxic element. Over 1 million kg of Cd is released into the atmosphere every year. Discharge of Cd into natural waters is mainly from electroplating industry and nickel-cadmium battery industry. Fertilizers and fungicides containing Cd are other sources of Cd pollution. Plants exposed to cadmium at toxic levels exhibit "chlorosis" and reduced growth. Cd in agricultural soils is mainly derived from the Cd present in fertilizers and sewage sludge applied in the crop fields. When grown in Cd contaminated soils, the roots of corn, oats, soybeans, tomatoes accumulate highest levels of Cd, whereas the aerial parts of carrot, potato, lettuce and tobacco accumulate highest levels of Cd.

Cadmium is highly toxic because of the absence of homeostatic control for this metal in the human body. About one third of the absorbed cadmium is stored in the kidney, which is the target organ. When excessive amounts of Cd^{2+} are ingested, it replaces Zn^{2+} at key enzyme sites and induce metabolic disorders. Cd interacts or competes with other metals such as Cu, Fe and Zn and induces the deficiency symptoms of these essential metals. The symptoms of Cd toxicity produced by enzymatic inhibition include hypertension, respiratory disorders, damage to kidney and liver, aminoaciduria, hypercalciurea, glucosuria, proteinuria, osteoporosis, formation of kidney stones etc.

III. Conclusion

Industrial effluents and urban pollution associated with sewage sludge, municipal waste water have increased the levels of Pb, Cd, As and Ni intake of the vegetables and soils. All these metals have toxic potential. Monitoring of heavy metals in plant tissues is essential in order to prevent excessive build-up of these metals in the human food chain. Also, efficient management techniques need to be implemented in order to prevent plants and vegetation from the harmful air pollutants. The situation, if mishandled, can cause irreparable harm.

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