Health Impacts of the Carbamate and Dithiocarbamate Pesticides: A Review

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Abstract- The accumulation of carbamate and dithiocarbamate pesticides in vegetables, fruits, and water, as well as their health effects on humans, are summarised in this study. Pesticide production and use, which are widely employed in agriculture to improve food production, forestry, and public health protection, is expanding year after year around the world. Pesticides containing carbamate and dithiocarbamate are broad-spectrum pesticides used against organisms that have developed resistance to organochlorine and organophosphorus pesticides. These compounds are also frequently employed as a peptide bond substitute in medicinal chemistry, as well as a starting material, intermediary, and solvent in the paint and polymer industries. Intake of carbamate and dithiocarbamate contaminated food by humans causes endocrine disruption, disrupting steroidogenesis and thyroid function, reproductive abnormalities, lowers oxidative stress, increases the risk of non-lymphoma, Hodgkin's and raises the chances of dementia.

Index Terms- Pesticides, Carbamate, dithiocarbamate, Water, Vegetables, Fruits

I. Introduction

Pesticides are defined as the chemicals used to destroy, repel or mitigate pests. The first synthetic pesticide was used in 1940. The pesticides not only improve the production and quality of agricultural produce but also reduce the mortality and morbidity of humans from vector-borne diseases. It is well-established fact that the food crisis worldwide has been decreased by the application of pesticides. Pesticides are also used in the sports field, roads, building to control pests like termites, cockroaches harmful to structure and human activities. These chemicals also help in growing off-season vegetables and fruits in more temperate weathers which help in improved economy of the developing countries. The use of synthetic pesticides for crop protection, food and material preservation from pests, plant regulators, desiccants, public health protection from vector-borne diseases like malaria, dengue fever, Japanese encephalitis, leishmaniasis has increased several folds since 1960 i.e. Era of the green revolution. It is reported that about 3.5 million tonnes of pesticides are consumed globally in the current year (Steingrímsdóttir et al., 2018) and it is also estimated that to increase agricultural production to feed 9.7 billion populations by 2050, the global consumption of the pesticides will enhance by 4% annually. The agricultural use of pesticides is more increasing in developing countries like Asia, South and Central America, Africa than in developed countries.

Only a minor portion of the applied pesticide reaches the target organisms while a major part of the applied pesticides harms non-targeted species (beneficial micro-organisms, insects, wildlife animals, birds, and fish), drinking water, surface water, air, soil, animal milk, breast milk, urine resulting in the ecological disturbances. Multiple pesticides residues and their metabolites since 1970 are reported in all the compartments of the environment, viz., air, groundwater, surface water, food chain, urine, animal milk, breast milk, fruits, vegetables, cereals, grains, animal feeds by the number of food scientists (Blaznik et al., 2016; Del Prado-Lu, 2015; Chourasiya et al., 2014; Witczak and Abdel-Gawad, 2014)

Most of the marketed pesticides contain 2 to 80% of the active ingredient. 'My Republica' on 24 July 2017 has published a report which states that most of the vegetables sold in the Kathmandu valley are contaminated with carbamate pesticides. Dithiocarbamates beyond their permissible limits have been reported in tomatoes (Atuhaire et al., 2017), kiwi, and pears (European Food Safety Agency, 2017).

As per World Health Organization (WHO) report, approximately one million people are affected by pesticides resulting in 4000- 20,000 deaths annually (Jia et al., 2020; Eddleston, 2020)

Indiscriminate and widespread use of these pesticides causes selection pressure on the microbiota. The persistence of the pesticides in the environment besides other factors also depends on the concentration and the types of the co-contaminants. A survey of the literature reveals that pesticides affect the respiratory system in humans which is an essential process for survival as it regulates oxygen-carbon dioxide exchange, balances acid and base tissue cells. Exposure of humans to pesticides damages the respiratory system and causes asthma, lung cancer, chronic bronchitis, chronic obstructive pulmonary disease (COPD) (Tarmure et al., 2020).

A significant positive correlation between pesticide exposure and respiratory problems i.e. asthma, lung cancer, COPD, coughing, allergic rhinitis, laryngeal irritation, wheezing, nausea etc have been reported by many researchers (Lekei et al., 2019; Jalilian et al., 2018; Buralli et al., 2018).

The present review throws light on the impact of uptake of carbamate and dithiocarbamate via food on human health.

II. Classification of Commonly used Pesticides

The commonly used pesticides based on the chemical properties are classified as:

2.1. Inorganic Pesticides: In the early sixteen-century arsenic sulphide was used as an insecticide in China. Later on salts of copper, boron, sulphur, zinc, selenium, mercury, lead, antimony, fluorine, selenium, thallium was used as a pesticide. But as these compounds have very little pesticidal activity and persist for a longer period in the environment were not widely used.

2**.2. Organic Pesticides**: The first organic pesticide was synthesized in 1937 nowadays worldwide 10,000 formulations of about 1500 pesticides are mostly used. The Organic pesticides based on their structure have been classified as:

2.2.1. Organochlorine pesticides: DDT, HCH, aldrin, dieldrin, endosulfan, heptachlor, dicofol, chlordane, and methoxychlor are some most widely used organochlorines pesticides. The first synthetic organic pesticide belongs to the organochlorine pesticides group; these pesticides have cyclodiene rings with five or more chlorine atoms. These pesticides are non-biodegradable and persist in the environment for a very long period (even for decades). These pesticides are fat-soluble and accumulate in the body of mammals. The pesticides of this group were widely used in an agricultural field and for public health purposes to control vector-borne diseases. After a survey of the literature, it can be concluded that the overuse of DDT has caused deposition of the DDT in the fat part of all the living organisms present in the universe.

2.2.2 Organophosphorus pesticides: Organophosphorus pesticides were first synthesized in 1937 from phosphoric acid. These pesticides are broad-spectrum, biodegradable, water-soluble, polar, non-lipophilic with higher pesticide potency were promoted as a more ecological alternative to persistent organochlorine pesticides. These pesticides inhibit/retards the enzymatic activities in the body. Organophosphorus pesticides are divided into three: aliphatics (e.g., malathion), aromatics (e.g. parathion), and heterocyclics (e.g., phosalone). Most of the organophosphorus pesticides are not as stable as organochlorine pesticides aromatic and sulphur containing organophosphorus pesticides is the exceptions. Globally Parathion, Malathion, Diazinon, dimethoate, chlorpyrifos, dichlorvos, and fenthion, glyphosphate are the most commonly used organophosphorus pesticides.

2.2.3. Carbamate and Dithiocarbamate Pesticides: These pesticides are synthetic their development, production and commercial use have been started in the 1970s. Dimetan was the first synthetic carbamate pesticide. Carbamate-bearing molecules are of therapeutic use. Carbamate pesticides in agriculture are used as insecticides, fungicides, nematicides, herbicides, acaricides, the carbamates are also widely used in medicinal chemistry as a peptide bond surrogate (Ghosh and Brindisi, 2015); as a starting material, as an intermediate, as solvent in the paint industry. Carbamate pesticides are broad-spectrum pesticides that are short-lived i.e. easily biodegraded and shows pesticidal activity against those pests which have attained immunity against organochlorine and organophosphorus pesticides. R-O-CO-N-CH (sub)-3) R' (where R is alcohol, oxime or phenol and R' is ether, H or alkyl group) is the general chemical structure of the carbamate pesticides. These pesticides are used as stomach, contact poison and fumigant. Most of the carbamate pesticides are less volatile and a fat-soluble majority of the carbamate pesticides persist in the environment. Nowadays about 50 carbamate pesticides are in use. Commonly used carbamate pesticides are carbaryl, oxamyl, carbofuran, aminocarb, aldicarb, carbendazim, fenobucarb, methomyl, and propoxur. Carbamate pesticides inhibit the activity of the enzyme acetylcholinesterase in the nervous system, inhibits the photosynthesis electron transport chain, block the nuclear division (Pujar et al., 2019; Mishra et al., 2021).

Dithiocarbamate pesticides which were introduced in the 1950s are used as insecticides, herbicides and fungicides in agriculture. Industrial and commercial use of these pesticides is as biocides, accelerating agent.Therapeutically these pesticides are used for the alcohol aversion. The general chemical structure of the dithiocarbamates is (R, R') N- (C=S)-SX, where R, R' can be an alkyl, alkenyl, aryl, or similar other groups, and X a metal ion. Based on the chemical structure the dithiocarbamate pesticides are classified into three groups (i) dimethyl dithiocarbamate (ii) ethylene bis dithiocarbamate and (iii) propylene bis dithiocarbamate. More than 15 dithiocarbamates are known, commonly used dithiocarbamate pesticides are thiram, manozeb, propineb, maneb, disulfiram, ziram, and ferbam.

The carbamate and dithiocarbamate pesticides undergo microbial degradation in soils and act as carbon and nitrogen source (Malhotra et al., 2021).

2.2.4. Pyrethrins and pyrethroids pesticides: Pyrethrins are natural pesticides extracted from the plant Chrysanthemum cineraria folium while pyrethroids pesticides are synthetic ones. Both the pyrethrins and pyrethroids pesticides are non-persistent, most of the pesticides of this group are water-insoluble, fat-soluble and have the least toxicity for humans. The pyrethrins and pyrethroids exist in two forms cis and Trans with a central ester bond of 3-phenoxy phenyl alcohol. Based on cyano radical the pyrethroids are classified into two groups, Type I- without cyano radical viz, permethrin, tetramethrin and Type II- with cyano radical viz. Deltamethrin, fenvalerate. The muscular system and the sodium channel of the target pest are affected by these pesticides.

2.2.5 Triazines: Triazine pesticides are six-membered heterocyclic compounds with three nitrogen and three carbon atoms. Though the first Trizine pesticide was synthesized in 1952 during the last 40 years the Triazine pesticides have been applied in the agricultural field mainly as a herbicide. These pesticides mimic hormonal activities and affect the sex ratio in amphibians and zebrafish. The metabolic degradation occurs via dealkylation and substitution. Commonly used atrazine are Atrazine, Simazine, Metribuzin, Oxadiazon, Prometryn, Terbuthylazine, Ametrine, and Terbutryne etc.

III. Sources of pesticides within the environment

Globally the pesticides are used to kill pests, increase food production, save humans from vector-borne diseases and develop chemical warfare agents. The development and production of pesticides especially in developing countries have been increased many folds after the 1960's green revolution. The use of pesticides in the agriculture sector is next to use of the fertilizers. The various modes of the entrance of the pesticides in the environment are (i) leaching from the soil surface e to the groundwater (ii) volatilization from the soil; plant leaves (iii) evaporation from surface water (iv) drifting and losses during application (iv) wind erosion

3.1 The main sources of environmental contamination by pesticides are:

The main application of pesticides is in agriculture activities and health protection to the citizenry. Pesticides protect plants from pests, weeds and other diseases and humans from vector-borne diseases such as malaria, dengue fever etc. Pesticides are also sprayed in the sports fields, urban green areas. The pesticides are an important ingredient of the building materials, in lice removal shampoos, pet shampoos, and of the material which is coated at the bottom of the boats. Leaks and spills from the storage sites, spilling during loading into the application equipment, rinsing containers, improper disposal of containers containing pesticides are the other sources of the entrance of the pesticides in the environment.

IV. Routes of Exposure

Humans and other organisms are exposed to pesticides via:

(i) Ingestion: Uptake through the mouth by eating food, vegetables, fruits, meat, milk, seafood including fish and by drinking water, beverages i.e. gastrointestinal route is called as ingestion.

(ii) Dermal: Absorption through skin/gills is known as dermal uptake. Pesticides in aquatic animals' are bioaccumulated via dermal contact. Humans uptake pesticides dermally during washing/ bathing by contaminated water, using shampoos containing pesticides and/or via facial.

(iii) Inhalation: Pesticides reaches the body of humans and/ or other animals by inhalation of the polluted air as dust fumes, aerosol and water vapours containing pesticides.

(iv) Occupational exposure: It occurs via contaminated clothing and the residues of the pesticides on the surface,

4.1. Routes of contamination of fruits, vegetables etc.:

The pesticides are bioaccumulated in the vegetables and fruits via absorption by the plants from the contaminated soil, irrigation by the pesticide-contaminated water and spraying of the pesticide(s) on the crop plant for pest control. As most of the pesticides do not degrade easily their biomagnification also occurs.

V. Pesticides in water, vegetables and fruits

The major factor of the pesticide contamination of the water is the leaching of the pesticides in the groundwater (Rai, and Pandey, 2017), which is caused due to the indiscriminate use of the pesticides; the water solubility of pesticides; improper irrigation, and rainfall. Globally about half of the groundwater samples contain pesticide (s) beyond permissible limits. Bansal (2008) during his long-term studies on groundwater contamination studies found that groundwater of Aligarh city contains pesticides beyond their permissible limits and the concentration increases with time. It was also reported that when this contaminated groundwater and sewage water is used for irrigation these pesticides are bioaccumulated in the vegetables and fruits.

Chowdhury et al. (2014) during their research studies found that samples of vegetables grown in Bangladesh contain carbamate pesticides beyond the acceptable limit. In the USA about 90% of samples of strawberries, apples, cherries, spinach, nectaries and kale are contaminated with two or more pesticides while 50% of samples are contaminated with multiple pesticides were the findings of the USA Environmental Working Group led by Meyer (2019). Few samples of kale contain up to 18 different pesticides.

The concentration of the carbamate and dithiocarbamate pesticides in vegetables, fruits, grains are grown globally are summarized in Table1.

VI. Pesticides in the milk

The milk, white fluid produced by the mammary glands of the mammals (cow, buffalo, goat, sheep, and human) is the main source of nutrition for young mammals till other types of food is not digested by them and an important component of the diet of elders (Kowalska et al., 2020; Sarsembayeva et al., 2020). The milk, complete food consists of the essential nutrient proteins, amino acids, vitamins, lactose, minerals, essential fatty acids, immunoglobulins, antimicrobial in the balanced ratio. The quality and the components and the ratio of the nutrients in the milk depends on the cattle, its breed, diet provided, the chemical composition of the soil of the area, the quality of drinking water, and the water used for irrigation of the crops. It is estimated that global milk consumption is 234 million metric tons i.e. the global average consumption of milk is approximately 100 kg per person. Globally most of the milk samples are contaminated with chlorinated pesticides, organophosphates, carbamates, dithiocarbamate pesticides, antihelminthic drugs, antibiotics, potentially toxic metals, etc. The source of the pesticides residues and their metabolites in the milk is the use of the contaminated water, the use of the contaminated fodder and the use of the pesticides on the animals to control ectoparasites. Globally 75-80% of the milk samples are contaminated with at least one pesticide and two or more pesticides are present in 60% of the milk samples (Jayraj et al., 2016). About 20% of the ingested chlorinated organic compounds are present in the milk (Aytenfsu et al., 2016). It is estimated that 90% of the average human intake of organochlorine compounds is via animal-origin food. The concentration of the carbamate pesticides in the milk samples are given in Table1.

VII. Impacts of pesticides on humans

Food is the major route (90%) of exposure to humans. Headaches, nausea, asthma, sore throat, eye irritation, skin irritation, diarrhoea, pharyngitis, nasal irritation, sinusitis, contact dermatitis, inflammation, endocrine disruption causing an exacerbation of asthma (Bourguet et al., 2016; Amr et al., 2015) occurs in human when they are exposed to pesticides for a short duration (Ngowi et al., 2017, while exposure of humans for a longer period causes birth defects, infertility, endocrine disruption, depression, diabetes, neurological deficits such as memory loss; weakness of the hands, legs; loss of concentration besides cancer (Mostafalou et al., 2013). Globally due to acute exposure to pesticides about three million serious poisonings and 220,000 deaths occur every year has been reported by WHO (2018). The presence of pesticides in the environment affects negatively the non-targeted organisms such as snakes, birds, lizards, amphibians, earthworms and causes disequilibrium in the ecology of the microorganisms which degrades the pesticides.

7.1 Effects of Carbamate Pesticides:

Exposure of humans to carbamate and dithiocarbamate pesticides causes hypersalivation, abdominal cramping, vomiting, diarrhoea, dyspnea, paralysis, miosis, muscle fasciculations, hypoxia, pulmonary oedema due to the retardation in the function of the acetylcholinesterase at nerves and neuromuscular junctions. Li et al., (2015) during their research study found that the carbamate and dithiocarbamate pesticides in human's results in reproductive disorders caused by cytotoxic and genotoxic effects in ovarian cells. Mnif et al., (2011); Soloneski et al., (2015) reported that these pesticides in human cells induces apoptosis and necrosis in T lymphocytes. These pesticides act as endocrine disruptors disrupt steroidogenesis and thyroid function (Silberman and Taylor, 2021).

Carbamate and dithiocarbamate pesticides in living organisms reduce oxidative stress by generating reactive oxygen species (ROS) (Prezenska et al., 2019), causing mitochondrial dysfunction (Dhouib et al., 2016), and endoplasmic reticulum. These pesticides also interfere with the specific function of the immune cells and the growth of leukocytes (Lee and Choi, 2020).

It has been experimentally proven that carbamate pesticides in human beings enhance the risk of tumours in the liver, kidney, thyroid, bladder, uterus, bones, brain and adrenal gland (Piel et al., 2019).

Dias et al (2014) reported that uptake of pesticide aminocarb by rats toxically affects the lymphoid organs in the rat; bendiocarb in rabbits affect the liver ultrastructure and degenerate testicular parenchyma (Holovska et al., 2014), carbaryl in rats causes histopathological changes, alters the mitochondrial enzymes, reduction in the fertility (Fattahi et al., 2012). Banji et al., (2014), Kaur et al (2012); reported that in rats carbofuran causes degeneration of DNA in enterocytes, nephrotoxic effects via Augmented oxidative stress. Carbofuran also causes liver toxicity in rats and humans. Methiocarb affects the liver, kidney, brain and testis of rats (Ozden et al., 2012). In the mouse, the methomyl causes negative effects on cell metabolism, cell membrane permeability and hepatic detoxification, testicular damage and sperm quality (Shalaby et al., 2010).

Dithiocarbamates in human causes neurotoxic effects and Parkinson like neurothrepy as these pesicides in brain alters the metabolism of the enzyme glycogen and brain glycogen phosphorylase (Mathieu et al., 2017)

VIII. Conclusions

- To increase the food production use of pesticides in the agriculture sector is crucial, secondly, pesticides play an essential role in the prevention of vector-borne diseases. But since the last 60 years in the agriculture and public health sector, pesticides have been used indiscriminately. The use of the carbamate and dithiocarbamate pesticides has been increased many folds during the last four decades as these are easily biodegraded and shows pesticidal activity against the pests which have attained immunity against organochlorine and organophosphorus pesticides.
- Globally all the environmental compartments i.e. surface water, groundwater, vegetables, fruits, other crops milk are contaminated by the carbamate and dithiocarbamate pesticides.
- One or more one carbamate and dithiocarbamate pesticides beyond their permissible limits have been found in 45-70% of the marketed vegetables and fruits in developing and developed countries.
- Pesticides are called silent killers as are easily bioaccumulated in the adipose tissues of humans, and animals and persist for a long period.
- Human health is under a serious threat due to carbamate and dithiocarbamate pesticides accumulation in the human body due to intake of contaminated food, milk, water etc. These pesticides inhibit the acetylcholinesterase enzyme activity; disrupts steroidogenesis and thyroid function; reduce oxidative stress by generating reactive oxygen species (ROS); enhance cardiovascular diseases; cause reproductive problems; neurological and immunodeficiency disorder.
- To minimize the negative impact of these pesticides on humans and the environment effective and convenient guidelines must be framed and those should be implemented.

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Table 1: The concentration of Carbamate and Dithiocarbamate pesticides in Milk, Vegetables, Fruits, Fish, cereals and pulses

SN	Pesticide	Water	Sediments	Milk	Fruits	Vegetables	Fish	Cereals/pulses
1.	Carbaryl	River Water-0.014-0.053 mg/L (Musa et al., 2019); Lake water 2.4 ng/L (Wang et al., 2021)	River-0.222-0.823 ug/kg (Musa et al., 2019)		Water melon-0.021-1.51 mg /kg (Kapeleka et al. 2020); Water Melon-0.30 ug/kg (Fatunsin et al., 2020); Cucumber-0.30 ug/kg (Fatunsin et al., 2020)	Tomato- 0.30-0.61 mg/kg[55]; Cabbage-0.30 ug/kg (Fatunsin et al., 2020); Cameroon pepper-0.30ug/kg(Fatunsin et al., 2020); Green pepper-0.30ug/kg (Fatunsin et al., 2020);Chili pepper-10.0 ug/kg (Fatunsin et al., 2020);Carrot- 0.30 ug/kg (Fatunsin et al., 2020); Lettuce-0.30 ug/kg (Fatunsin et al., 2020); Tomato-10.0 ug/kg (Fatunsin et al., 2020); Scotch Bonnet-0.30 ug/kg (Fatunsin et al., 2020)	Brain-2.17-4.67ug/kg (Vengayil, 2011): Liver 1.80-3.17ug/kg (Vengayil, 2011) ; Abdominal muscles-1.19-1.98ug/kg (Vengayil, 2011)	Millet-0.30ug/kg (Fatunsin et al., 2020); Maize-0.30ug/kg (Fatunsin et al., 2020);wheat-0.30ug/kg (Fatunsin et al., 2020); Sorgum-0.30ug/kg (Fatunsin et al., 2020);beans-0.30ug/kg (Fatunsin et al., 2020) ;cowpea-0.30ug/kg (Fatunsin et al., 2020);

2.	Carbofuran	Lake water- 0-0.0387 ug/L (Uddin et al., 2013); River water-0.0194-0.072 mg/L (Musa et al., 2019)	River Sediment -0.365-1.319 ug/kg (Musa et al., 2019)	Buffalo-0.09-0.61 mg/L; Cow-0.10-0.84 mg/L; Goat milk-0.02-0.74 mg/ L (Shahzadi et al., 2013)	Watermelon-0.07 mg/kg [54]; Water Melon-0.25 ug/kg (Fatunsin et al., 2020); Cucumber-1.00 ug/kg (Fatunsin et al., 2020)	Okra 0.021 mg/kg Bhatt et al., 2019); Brinjal 1.789 mg/kg (Bhatt et al., 2019); Vegetables-0.0001-0.0181 mg/kg (Kapeleka et al., 2020); Cabbage-1.00 ug/kg (Fatunsin et al., 2020); Cameroon pepper- 1.0 ug/kg (Fatunsin et al., 2020);Green pepper-10.0 ug/kg (Fatunsin et al., 2020);Chili pepper-10.0 ug/kg (Fatunsin et al., 2020);Carrot- 0.25 ug/kg (Fatunsin et al., 2020); Lettuce-0.25 ug/kg (Fatunsin et al., 2020); Tomato-0.25 ug/kg (Fatunsin et al., 2020); Scotch Bonnet-0.25 ug/kg (Fatunsin et al., 2020)	Brain-0.11-2.17ug/kg (Vengayil, 2011); Liver 0.31-0.40ug/kg (Vengayil, 2011); Abdominal muscles-2.19-3.32ug/kg (Vengayil, 2011)	Millet-0.25ug/kg (Fatunsin et al., 2020); Maize-0.25ug/kg (Fatunsin et al., 2020);wheat-0.25ug/kg (Fatunsin et al., 2020); Sorgum-0.25ug/kg (Fatunsin et al., 2020);beans-0.25ug/kg (Fatunsin et al., 2020);cowpea 0.25ug/kg (Fatunsin et al., 2020)
3	Methomyl			325 ug/kg (Dahshan et al., 2016)		Leafy vegetables-0.01-0.02 mg/kg (Elgueta et al., 2017); Cauliflower 0.9ug/kg (Farina et al., 2016); Spinach 6.0ug/kg (Farina et al., 2016) ;Broccoli- 11 ug/kg(Farina et al., 2016);Mustard-6.4ug/kg (Farina et al., 2016);Tomato-0.005-0.008 mg/kg (Ramadan and Abdel-Hamid, 2020); Cucumber-0.009-0.222mg/kg (Ramadan and Abdel-Hamid, 2020); Chilli pepper-0.005-0.199 mg/kg (Ramadan and Abdel-Hamid, 2020); Cabbage- 0.006-0.071 mg/kg (Ramadan and Abdel-Hamid, 2020); Onion-0.009-0.054 mg/kg (Ramadan and Abdel-Hamid, 2020); Eggplant-0.008-0.307 mg/kg (Ramadan and Abdel-Hamid, 2020); Potato- 0.005-0.010		

						mg/kg (Ramadan and Abdel-Hamid, 2020);		
4	Oxamyl					Tomato- 0.0-0.09 mg/kg (Hassine et al., 2014); Cucumber-0.0-0.98 mg/kg (Hassine et al., 2014)		
5	Dithiocarbamates				Peach-0.06-1.7mg/kg; Guava-0.04-0.4 mg /kg; Kaki-0.03-7.09 mg/kg; Cashew apple- 0.05-0.2 mg/kg (Jardim et al., 2014);	Carrots-7.79 mg/kg (Ahoudi et al., 2018); Vegetables (Unwashed) - 0.0-3.45 mg/kg (Atuhaire et al., 2017; (Washed)-.0-0.74 mg/kg (Atuhaire et al., 2017); Tomato-0.0-1.33mg/kg; 0.0-1.87 mg/kg; 1.44-3.99 mg/kg; 1.54-4.06 mg/kg;0.00-4.65 mg/kg (Kavatsurwa et al., 2014);		
6	Methiocarb				Water Melon-2.00 ug/kg (Fatunsin et al., 2020); Cucumber-1.00 ug/kg (Fatunsin et al., 2020)	Vegetables-0.0035-0.0479 mg/kg (Kapeleka et al., 2020); Cabbage-1.00 ug/kg (Fatunsin et al., 2020); Cameroon pepper-20.0 ug/kg (Fatunsin et al., 2020);Green pepper-20.0 ug/kg (Fatunsin et al., 2020);Chili pepper-20.0 ug/kg (Fatunsin et al., 2020);Carrot- 0.30 ug/kg (Fatunsin et al., 2020); Lettuce-0.30 ug/kg (Fatunsin et al.,		Millet-0.30ug/kg (Fatunsin et al., 2020); Maize-0.30ug/kg (Fatunsin et al., 2020);wheat-0.30ug/kg (Fatunsin et al., 2020); Sorgum-0.30ug/kg (Fatunsin et al.,

						2020); Tomato-30.0 ug/kg (Fatunsin et al., 2020); Scotch Bonnet-20.0 ug/kg (Fatunsin et al., 2020)		2020);beans-0.30ug/kg (Fatunsin et al., 2020);cowpea-0.30ug/kg (Fatunsin et al., 2020)
7	Bendiocarb					Vegetables-0.0057-0.0624 mg/kg (Kapeleka et al., 2020)		
8	Fenobucarb					Vegetables-0.0001-0.0001 mg/kg (Kapeleka et al., 2020)		
9	Fenothiocarb					Vegetables-0.0001-0.0001 mg/kg (Kapeleka et al., 2020)		
10	Propoxur	Ground water-0.072ug/L (Nantia et al., 2017)			Water Melon-0.24 ug/kg (Fatunsin et al., 2020); Cucumber-0.24ug/kg (Fatunsin et al., 2020)	Cabbage-0.24 ug/kg (Fatunsin et al., 2020); Cameroon pepper-10.0 ug/kg (Fatunsin et al., 2020);Green pepper-0.24 ug/kg (Fatunsin et al., 2020);Chili pepper-10.0 ug/kg (Fatunsin et al., 2020);Carrot- 0.24 ug/kg (Fatunsin et al., 2020); Lettuce-0.24 ug/kg (Fatunsin et al., 2020); Tomato-0.24 ug/kg (Fatunsin et al., 2020); Scotch Bonnet-0.24 ug/kg (Fatunsin et al., 2020)		Millet-0.24ug/kg (Fatunsin et al., 2020); Maize-0.24ug/kg (Fatunsin et al., 2020);wheat-0.24ug/kg (Fatunsin et al., 2020); Sorgum-0.24ug/kg (Fatunsin et al., 2020);beans-0.24ug/kg (Fatunsin et al., 2020);cowpea-0.24ug/kg (Fatunsin et al., 2020)

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11	3-Hydroxy carbofuran				Water Melon-2.00 ug/kg (Fatunsin et al., 2020); Cucumber-4.00 ug/kg (Fatunsin et al., 2020)	Cabbage-2.0 ug/kg (Fatunsin et al., 2020); Cameroon pepper-50.0 ug/kg (Fatunsin et al., 2020);Green pepper-70.0 ug/kg (Fatunsin et al., 2020);Chili pepper-70.0 ug/kg (Fatunsin et al., 2020);Carrot- 2.0 ug/kg (Fatunsin et al., 2020); Lettuce-2.0 ug/kg (Fatunsin et al., 2020); Tomato-50.0 ug/kg (Fatunsin et al., 2020); Scotch Bonnet-20.0 ug/kg (Fatunsin et al., 2020)		Millet-0.30ug/kg (Fatunsin et al., 2020); Maize-0.30ug/kg (Fatunsin et al., 2020);wheat-0.30ug/kg (Fatunsin et al., 2020); Sorgum-0.30ug/kg (Fatunsin et al., 2020);beans-0.30ug/kg (Fatunsin et al., 2020) ;cowpea-0.30ug/kg (Fatunsin et al., 2020)
12	Carbamate Pesticides-	Ground water-0.003-0.397ug/L (Nantia et al., 2017); River water 2.7-11.7 ng/L (Wang et al., 2021)					Whole body-0.11-0.25 ug/g (Adegun., 2020); 0.21-0.24 ug/g (Adegun., 2020); 0.14-0.30 ug/g (Adegun., 2020); 0.14-0.26 ug/g (Adegun,2020)	