Pesticide Impact on Human Health

Sonowal Sarojmoni*, Dutta Mridusmita¹, Phukon Himadree¹, Jain Gunjan¹ and Jain Monika²

¹Department of Life Sciences, Dibrugarh University, Assam 786004, India
²Department of Molecular Biology and Biotechnology, Tezpur University, Assam 784028, India

*Corresponding Author

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Abstract: Use of pesticides have contaminated every ecosystem on the earth since pesticide residues have been reported in water, air, soil, crops, non-target plants and animals. Due to the toxicity, pesticides are potentially hazardous to humans, animals, other organisms, and the environment. Therefore, people who use pesticides or regularly come in contact with them, must understand the relative toxicity, potential health effects, and preventative measures to reduce exposure to the products. Symptoms of pesticide poisoning in human are either topical (develop at the site of pesticide contact) or systemic (occur away from the original point of contact as a result of the pesticide being absorbed into and distributed throughout the body). Common signs and symptoms of acute exposure to active ingredients of insecticide include abdominal pain, diarrhoea, dizziness, excessive salivation and tearing, headache, loss of consciousness, Malaise, muscle twitching and weakness, nausea, nervous system depression, pinpoint pupils, respiratory depression, seizures, sweating, vomiting, coma and death in severe case. Exposure of pesticides may result into fatal diseases like cancers, leukaeemia and asthma. The risk of health hazards due to pesticide exposure depends on toxicity of the ingredients and the level of exposure. Additionally, children, pregnant women and aging populations are more sensitive to the effects of pesticides. This review provides an overview on harmful effects of pesticides on human health with reference to routes of human exposure, risks of exposure to human and impact on human health.

Keywords: Pesticides, Toxicity, Health hazards, Symptoms, Exposure, Bio-pesticides


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Introduction

The agricultural chemicals are used to control pests such as fungi, nematodes, mites, insects, rodents and viruses. Agrochemicals enhance the efficient and economic production of nutritious food and fibre products, reducing soil erosion and maintaining human health and lifestyles for world population. Compounds such as herbicides, fungicides, insecticides, nematicides, rodenticides,
molluscicides etc. are categorized as 'agricultural chemicals/agrochemicals' (Kunal et al., 2020).

Shah (2020) documented that use of pesticides is indispensable in agricultural production and there is a need for pesticide based pest control and food security in the future. Along with the control of pests (insects, rodents, microbes, fungi and weeds), pesticides are also used to control vector-born infectious diseases (Zika virus, Lyme disease, and rabies), household pests (cockroaches, bed bugs), and as repellents etc.

Sanchez-Bayo (2011) described that, till date about 835 chemical compounds are used as agricultural pesticides and nearly 1300 products were registered. Of these products, 31% are herbicides, 21% insecticides, 17% fungicides, 9% acaricides and 2% rodenticides. Remaining 20% of products are used to control snails, algae, nematodes along with plant growth regulators and natural or artificial pheromones.

Though pesticides are used in agriculture to prevent, remove, or control harmful pests, they cause hazards towards the environment and human health (Kim et al., 2017). Worldwide surveys on agrochemicals have documented the contamination and impact of agrochemical residues in soils, and terrestrial and aquatic ecosystems including coastal marine systems, and their toxic effects on humans and nonhuman biota (Rajendran, 2003). Although persistent organic chemicals have been phased out and replaced by more biodegradable chemicals, contamination by legacy residues and recent residues still impacts on the quality of human food, water, and environment (Carvalho, 2017).

Hassaan and Nemr (2020) stated that pesticides in water resources adversely affect the ecosystems and humans. Pesticides also acts as probable mutagens and cause alteration in the base constituents in DNA. Globally, about 1000,000 human being are affected by acute poisoning by contact with pesticide and each year, a death rate between 0.4 and 1.9% is recorded. This could be attributed to the work-related contact with pesticides to brought 70% of these mortalities. Bertero et al. (2020) described that constant contact to lower pesticides dosages was associated with a group of syndromes with tumours and nervous system disorders. The Aral Sea area is a typical example of the impact of pesticide pollution on human health.

Kumar and Kumar (2019) reported that pesticides can move into the human body by oral, inhalation or dermal exposure, and are responsible for respiratory disorders, cancer, skin problems, endocrine disruption, and reproduction failures. Toxicants from the pesticides pose serious risk, both to the humans and animals and negative health impacts caused by pesticides depend upon the degree and span of exposure. Health impacts of pesticides range from mellow sensitivities, rashes, breathing challenges, neurotoxicity and reproductive complications to deadly chronic diseases like cancer (Tomer et al., 2015).

UNEP (1993) reported that human health impacts of pesticides include cancer, haematological morbidity, pulmonary dysfunction, immune system deficiencies and inborn deformities. Farm employees who are end users for application of pesticides, have more chances of skin contact intoxication and inhalation throughout handling and/or treatment of pesticides to crops (Bergmann, 2019). According to Kumar and Kumar (2019), kids, pregnant ladies, and older people manifest serious impacts due to exposure to pesticides. Benbrook (2016) quoted that herbicide glyphosate, used commonly in agriculture and in cities for the control of weeds, is a main carcinogenic agent and is a widespread concern about effects on human health.

Dabady and Tulk (2015) reported that indiscriminate use of pesticides in agriculture has raised serious concerns about health issues. According to WHO (1990), acute pesticide poisoning (APP) affects 3 million people and accounts for 20,000 unintentional deaths per year, with 99 per cent of these fatalities believed to be
in developing countries. Bonner et al. (2016) described that long term impacts of pesticides was life threatening due to lymphomas, leukemia, soft tissue sarcomas, mind, bone and stomach malignant growths, harm to peripheral and central nervous system, birth defects, reproductive complaints, disruption of the immune system and even death.

Many peer reviewed scientific studies and the consolidated knowledge about the adverse impacts of pesticides on human health are available, there are still gaps in knowledge and information that need to be addressed (UNEP, 2022). To overcome the knowledge gaps and further research on synthesis of environment friendly and less toxic pesticides, present study was undertaken.

Definition of Pesticides:
Table 1 illustrates the definition of pesticides as described by some researchers.

This article reviews the pesticides with respect to definition and harmful effects on human health. Review method adopted was based on the scientific literature survey from databases such as Scopus, Medline, EMBASE, Web of Science and Science Direct. The relevant data and information were collected from the thorough study of the journal articles, research papers, reports and various literatures. The keywords used for reviewing the literature were the ones that refer to the issues concerning the pesticides. For literature search, keyword "pesticides" is combined with: routes of human exposure (occupational, non-occupational, dermal, oral, respiratory and eye), risks of exposure (toxicity and exposure) and impacts on human health (acute, chronic, neurotoxic, genotoxic, carcinogenic and reproductive).

Harmful Effects of Pesticides on Human Health:
Routes of human exposure to pesticides (Kumar and Kumar, 2019):
• Movement of pesticides in human body: Dermal, oral, eye and respiratory pathways.

• Type of Contact: Dermal, oral, or respiratory (inhalation).

• Hazard of pesticide pollution: Rises on the dosage (concentration) and basic periods (duration of exposure), instead of poisonous quality of chemical.

• Exposure to pesticides: Occupational, household use and agricultural along with on golf courses, around major roads etc.

• Human introduction to pesticides: Food chain, water, air, soil, fauna and flora.

• Fate of pesticides in human body: Dispersed all over the body through the circulatory system and excreted through skin, urine, and exhaled air.

❖ Actively through occupational exposure (Shah, 2020):
• Manufacturing, transportation, sale, and application process.

• Pesticide contaminated clothing and equipments of employee working in agriculture industry pose risk of cancer in their children.

❖ Passively through non-occupational exposure (Shah, 2020):
• Ingestion of pesticides residues with contaminated food and water.

• Inhalation of pesticides droplets from the air through drift from point of release or fumigation.

• Residual indoor sprays and outdoor fogging of insecticides.

• Treatment of ectoparasites in pets, e.g. fleas, ticks, mites etc.

➢ Dermal exposure (Beard et al., 2014):
• Most common type of pesticide exposure by applicators.

• Dermal assimilation occur due to sprinkle, spill, spray drift, mixing, stacking, arranging, and cleaning of pesticides.
Table 1: Selected definitions of pesticides

<table>
<thead>
<tr>
<th>Reference</th>
<th>Definition of Pesticide</th>
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<tbody>
<tr>
<td>Padmajani et al. (2014)</td>
<td>Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest.</td>
</tr>
<tr>
<td>Kumar and Kumar (2019)</td>
<td>A sort of chemicals which are formed to get rid of a pest or halt its reproduction termed as pesticides.</td>
</tr>
<tr>
<td>Shah (2020)</td>
<td>A pesticide is any substance which is used to prevent, destroy or repel any pest from causing any damage.</td>
</tr>
</tbody>
</table>

- Absorption from exposure to large quantities of pesticide residues.
- Impacted by the sum and span of exposure, materials present on the skin, temperature, moistness and use of individual protective device.
  - **Oral ingestion** (Damalas and Eleftherohorinos, 2011):
    - Consumption of the pesticide through the mouth into the digestive tract.
    - Occur through occupational, intended or unintentional pesticide use.
    - Spray vapour enters the nose and mouth and is gulped during spraying.
    - When a pesticide is introduced through oral contact, the most serious poisoning may result.
    - Happens by chance due to inattention or intended reasons towards pesticides.
    - Commonly happen during transfer of pesticides from their marked container to an unlabeled bottle or food vessel.
    - Labours handling pesticides or equipment for their application can consume pesticides if they don’t wash their hands before eating or smoking.
  - **Respiratory exposure** (Bergmann, 2019):
    - Happen due to inward breath of pesticides resulting harm to throat, nose and lung tissues.
- Greater respiratory exposure occur when low-volume equipment is used for application of concentrated pesticide, as it creates minor drops.
  - **Eye exposure** (Fareed et al., 2012):
    - Involve chemical damage for tissues of the eye.
    - Can cause genuine or even lethal disorder.
    - Granular pesticides cause a specific danger to the eyes.
    - Generally result from use of power equipment for pesticide application.
    - Use of eye safety devices during mixing concentrated or poisonous pesticides.
    - Defensive face shields or goggles should worn while spraying pesticides.
- **Risks of pesticides exposure to human** (Shah, 2020):
  - Depends on the toxicity and the exposure to the pesticide.
  - **Toxicity**:
    - ✓ Measure of harmfulness of a pesticide.
    - ✓ Measured as lethal dose (LD$_{50}$).
    - ✓ LD$_{50}$ is the quantity of pesticide in mg/kg of body weight and will kill 50% of the test animals within unit time.
    - ✓ LD$_{50}$ value depends on the route of entry of a pesticide.
Acute toxicity: Short term exposure to a single dose with health effects.

Chronic toxicity: Repeated exposure to a pesticide over a longer period of time from several months to years.

- **Exposure:**
  - Measure of the contact (duration) with a pesticide.

**Impacts of pesticides on human health (Shah, 2020):**

**Acute effects of pesticide exposure (Benka-Coker et al., 2020):**

- **Short-term exposure:** Stinging eyes, rashes, blisters, skin irritations, blindness, nausea, dizziness, diarrhoea and death.

- **Respiratory system:** Chronic cough, dyspnea, wheezing and expectoration, decreased lung capacity, asthma, bronchitis, burning in the throat and lungs, airway congestion, cramps, skin peeling, diarrhoea, headache, chest pain, weakness, cough and skin irritation.

- **Effects of pesticides exposure on children:** Asthma, wheezing, coughs, acute respiratory infections, hay fever, rhinitis, eczema, chronic phlegm, and lung function impairments. Nausea, vomiting, muscle weakness, respiratory effects, headache, lethargy, and tachycardia.

- **Symptoms:** Headaches, body aches, skin rashes, poor concentration, nausea, dizziness, impaired vision, cramps, panic attacks, and coma and death in severe cases (Lee et al., 2011).

- **Immediate effects of pesticide exposure:** Headache, stinging of the eyes and skin, irritation of the nose and throat, skin itching, appearance of the rash and blisters on the skin, dizziness, diarrhoea, abdominal pain, nausea and vomiting, blurred vision, blindness and very rarely death (Hicks, 2013).

**Chronic effects of pesticide exposure (Nicolopoulou-Stamati et al., 2016):**

- Any harmful effects that occur from small doses repeated over a period of time are referred as 'chronic effects' (Mostafalou and Abdollahi, 2012).

- Symptoms are not noticed immediately but appears at a later stage.

- Chronic effects of pesticides are categorised into three groups: neurotoxic effects, genotoxic and carcinogenic effects and reproductive effects.

- Symptoms of chronic effects: Birth defects, toxicity to a foetus, and production of benign or malignant tumours, genetic changes, blood disorders, nerve disorders, endocrine disruption, and reproduction effects (Mostafalou and Abdollahi, 2012).

- Organ damage: Damages liver, lungs, kidneys and may cause blood diseases (Mahmood et al., 2016).

- Chronic effects of pesticide exposure on human include cancers, birth defects, reproductive harm, neurological and developmental toxicity, immuno-toxicity, and disruption of the endocrine system (Shah, 2020).

- Damage immune system and can cause hypersensitivity, asthma and allergies (Mahmood et al., 2016).

  - **Neurotoxic effects (Mlesi et al., 2020):**

    - Adverse effect on the central or peripheral nervous system.

    - Polyneuropathy: Death of nerve cell due to disruption of cytoskeleton, oxidative stress, calcium overload, and damage to mitochondria.

    - Neuropsychiatric disorders: Anxiety and depression due to poisoning from organophosphate (OP) pesticides.
• Intermediate syndrome and OP-induced delayed polyneuropathy (OPIDP).

• Neurological diseases: Parkinson’s disease (PD), seizure, cognitive dysfunction, memory deficits, dementia, depression, and Alzheimer’s disease.

• Abnormal Neuropsychological performance: General mental status, language, memory, attention, executive function, praxis and psychomotricity.

• Deterioration of cognitive functions: Verbal fluency, visual and auditory memory, lower processing speed in children and lower IQ.

• Tremor syndrome: Behavioural arousal, aggressive sparring, increased startle response, and whole-body tremor, and prostration.

• Salivation syndrome: Profuse salivation, coarse tremor and clonic seizure.

• Affect learning, memory, emotions, movement with hearing.

• Neuro-developmental disorders: Attention-deficit disorder, autism spectrum disorder, and cognitive and behavioural dysfunction.

• Insomnia, headaches, mood swings, memory loss & decreased concentration.

• Neurological health effects: Loss of coordination and memory, reduced visual ability and reduced motor signalling (Lah 2011).

➤ Genotoxic and Carcinogenic effects (Ellsworth et al., 2018):

Genotoxic effects (Lorenz, 2009; WHO. 2020):

• Alterations, damage or ruptures in genetic material (DNA).

• Affect enzymatic processes of repair, genesis or polymerization of proteins.

• Impaired embryonic development or development of cancer.

• Pesticides exposure can cause genomic damage.

• Types of genetic damages caused by pesticides:

  ✓ Pre-mutagenic damage: Breaking of DNA strand and DNA adducts.

  ✓ Gene mutations: Insertion, deletion, inversion and translocation.

  ✓ Chromosomal aberrations: Aneuploidy (loss/gain of whole chromosome), clastogenicity (deletion/breaks) and chromosomal rearrangements.

• Pesticides causing genetic damage: Malathion, carbofuran, triflumuron, imidacloprid, acetamiprid, thiamethoxam, pentachlorophenol, emamectin benzoate and tembotrione.

➤ Carcinogenic effects (UNICEF, 2018):

• Development of cancer: Interactions of genetic and lifestyle factors (diet, stress, physical and biological agents, infections, and exposure to the hazardous chemical substances).

• Cancer by pesticide residues: Leukaemia, brain cancer, lymphoma, cancer of the breast, prostate, ovaries, and testes (Mahmood et al, 2016).

• Non-Hodgkin lymphoma (NHL) and Hodgkin lymphoma (HL): Diverse group malignancies developed in patients with immune dysfunction. Pesticides with NHL risk: Terbufos, dimethoate, malathion and chlorpyrifos.

Pesticides with HL risk: 2,4-D (2,4-dichlorophenoxyacetic acid), dichlorprop:

• Leukemia (Blood cancer) (Bailey et al., 2015): Chronic myelocytic leukemia (CML) and acute myeloblastic leukemia (AML). Occupational exposure: Livestock farmers and golf course superintendents. Found to be higher in women.
- Breast cancer (Rajveer et al., 2019): Caused by endocrine disrupting pesticides (EDPs). EDP with risk of breast cancer include insecticides (Malathion), fungicides and herbicides.
- Prostate cancer: Most common cancer in men and is androgen dependent. Caused by hormone disrupting pesticides like Endosulfan, DDT, Methyl bromide, Dichlone etc.
- Hepato-cellular carcinoma (HCC): Risk factors: Endosulfan, DDT, Carbaryl, Fluopyram, Carbendazim, Dicamba, Acetochlor etc.
  > Reproductive effects:
  - Reduce reproductive capabilities: Stillbirth, birth defects, spontaneous abortion and infertility (Lah, 2011).
  - Risk factor: Endocrine disrupting chemicals (EDCs). Methyl bromide (CH\textsubscript{3}Br).
  - Organophosphorous components present in the pesticides affect the male reproductive system and reduce the sperm activities (e.g., counts, motility, viability and density), inhibition of spermatogenesis, reduction of testis weights, damaging sperm DNA, and increasing abnormal sperm morphology (Mehrpour et al., 2014).
  > Asthma:
  Amaral (2014) have reported an association between pesticide exposure and symptoms of bronchial hyper-reactivity and asthma. Pesticide exposure leads to onset of asthma by irritation, inflammation, immuno-suppression, or endocrine disruption. Exposure of organophosphate (OP) pesticides in childhood is associated with respiratory symptoms, ocular-nasal symptoms and active asthma among women farm workers in Africa (Kim et al., 2017).
  > Diabetes:
  Exposure to organochlorine pesticides (DDT, DDE, oxychlordane, trans-nonachlor, hexachloro-benzene, and hexachlorocyclohexane) poses a serious risk of onset of diabetes (Jaacks and Staimez, 2015; Kim et al., 2017).

Conclusion

The key to reducing health hazards when using pesticides is to always limit your exposure by wearing Personal Protection Equipment and use a low-toxicity pesticide when available. Reading the label and practicing safe work habits will minimize hazards from the use of pesticides. Development of eco-friendly pesticide alternatives (e.g. bio-pesticides) and Integrated Pest Management (IPM) techniques are the effective ways to reduce the impacts of pesticides on human health (Kim et al., 2017).

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References


