Impact of Environmental Toxicants on Biodiversity

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***Abstract*-The impacts of environmental toxicants on biodiversity were examined with the view of investigating how they occur and to propose possible measures to be taken in reducing them. Environmental toxicants are substances present in the environment in a state or concentration that is capable of causing harm or injury on exposure through a particular route and circumstances on humans, plants or any other living organism. Toxicants have played a key role in changing the distribution pattern of many animal and plant species by direct toxicity or by affecting their habitat and/or their source of food. The paper reviewed different classes of environmental toxicants such as carcinogens, mutagens, teratogens, allergens and neurotoxicants; their sources which may be point or non-point defending on whether or not their point of entry into the environment is identifiable, exposure and toxicity in the body system which may be acute or chronic. The entry and fate of these toxicants in the environment and their harmful effect on individuals, populations, communities and ecosystems were also documented. Toxicants persistence in the environment as well as their impacts on biodiversity survival was also reviewed. The paper suggests options that could be helpful in mitigating the effect of toxicants in the environment. These measures include public awareness, banning from both production and use, restriction of exposure and measures to reduce effect.**

Keywords: Toxicants, Biodiversity, Xenobiotics, Carcinogens

I. INTRODUCTION

The term toxicant literally means a poison i.e. any substance that has a harmful effect on a living system. It is not easy to say that any substance is not a toxicant or poison because it is the dose that makes a poison [1]. Vinyl chloride can be taken as an example. It is a potent hepatotoxicant at high doses, a carcinogen with a long latent period of exposure at lower doses and apparently without effect at very low doses [2]. Clinical drugs are poignant example because, although therapeutic at some doses, they are not without deleterious side effects and may be lethal at higher doses. Aspirin, for example, is a safe drug at recommended doses, but chronic use can cause deleterious effects on the gastric mucosa, and it is fatal at a dose of about 0.2 to 0.5 g/kg [3]. An environmental toxicant or poison can therefore be defined as substances present in a state or dose that is capable of causing harmful effect on exposure on living organism in the environment [1].

II. CLASSIFICATIONS OF TOXICANTS

***A. Carcinogens*:** Toxicants that causes cancer. E.g Radiations, Chemicals such as Polycyclic aromatic hydrocarbons, aromatic amines and halides, benzene, vinyl chloride, certain metals, diet, and tobacco smoke [4].

B. Mutagens: Mutagens are toxicants that causes mutations in DNA. Many mutagens have also been shown to be carcinogens as well. Commonly found mutagens that are of most concern to humans include UV light, ionizing radiation, microtoxins, and organic and inorganic chemicals. Some chemicals are also mutagens, they include: Nitrosamines found in Pyrolysis products of tryptophan such as broiled meat, beer and whisky, Benzo(a)pyrene in cigarettes and wood smoke, Benzidine found in textile dyes and manufacture of paper and leather [4].

C. Teratogens: toxicants that causes birth defects E.g Thalidomide. Thalidomide was a drug used in the 1950s as a sleeping pill during pregnancy but turned out to be a potent teratogen. Pregnant women who had taken the drug gave birth to children suffering from different malformations of organs [3].

D. Allergens: Toxicants that causes unnecessary immune response. E.g Pollens and Dust [4].

E. Neurotoxins: Affect nervous system E.g *Clostridium* toxins and Heavy metals [3].

F. Endocrine Disruptors: Toxicants that interfere with hormonal function in the body. e.g. DDT, and DES [4]. Endocrine Disrupters mimic the hormones in the body [5]. They interfere with the production, release, metabolism, binding or elimination of natural hormones [6].

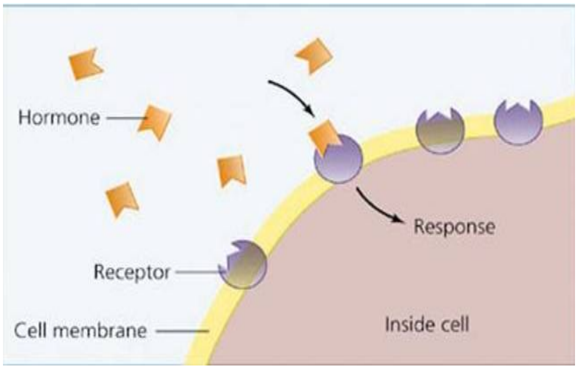

FIGURE 1: Normal Hormone Binding

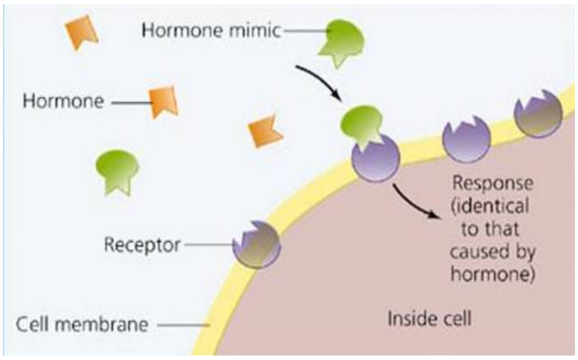

FIGURE 2: Hormone mimicry

III. SOURCES OF TOXICANTS

A. Point Sources: These are discrete discharges of chemicals that are usually identifiable and measurable, such as industrial or municipal effluent outfalls, oil spills and other stationary atmospheric discharges [2].

B. Non-point Sources: These are sources that are more diffuse over large areas with no identifiable single point of entry such as agrochemical (pesticide/fertilizer) runoff, mobile sources emissions (automobiles), atmospheric deposition, and groundwater inflow [2].

IV. TOXICITY OF TOXICANTS

A. Types of Toxicity/Exposure

i. Acute Toxicity: Toxicity elicited as a result of short-term exposure to a toxicant. The effect of toxicants in acute toxicity is immediate and is usually associated with accidents. Example: corrosive chemical effect on the skin [7].

ii. Chronic Toxicity: Toxicity elicited as a result of long-term exposure to a toxicant. In chronic toxicity, the effect is delayed and do not occur until after the lapse of some time. For example Carcinogenic effects of many chemicals usually have a long latency period, often 20 to 30 years after the initial exposure, before tumors are observed in humans [4].

V. Factors Affecting Toxicity

Not all individual organisms are equal. Sensitivity to toxicant can vary with sex, age, weight, etc. Example: older people or those in poor health are more sensitive to toxicants [4].

VI. Dose-Response Analysis

Dose-Response Analysis is the method of finding out the toxicity of a substance by measuring response to different doses of the toxicant compound in laboratory animals. Laboratory mice and rats breed quickly, and give data relevant to humans because they share similar physiology with humans. Responses to doses are plotted on a dose-response curve (Fig.1 and 2); dose-response curves allow toxicologist to predict effects of higher doses. The main aim of dose response analysis is to get information useful in establishing relationship between the level of contamination and the possibility or magnitude of an adverse effect. In most curves, response increases with dose. But this is not always the case; the increase may not be linear. With endocrine disruption, it may decrease. Threshold-dose is the dose at which response begins and LD50 dose is the dose lethal to 50% population of the subject animal [8].

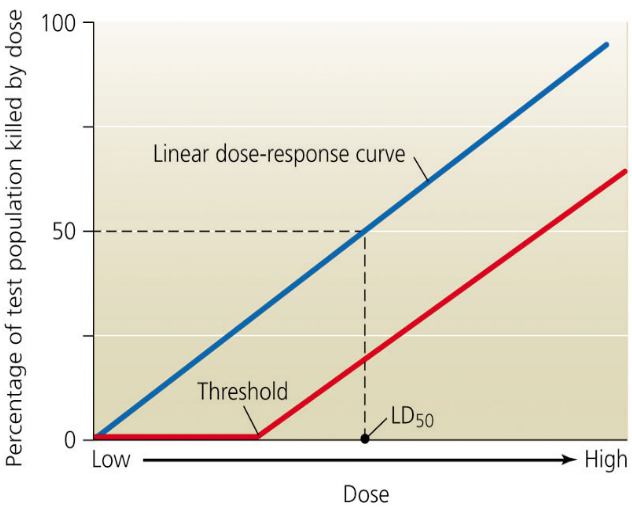

FIGURE 3: Dose-Response Curve

VII. FATE OF TOXICANTS IN THE BODY (TOXICOKINETICS)

The following processes determine the fate of toxicants in the body.

***A. Absorption of Toxicants*:** The main routes of absorption include the skin and mucous membranes and gastrointestinal tract [7].

***B. Distribution of toxicants in the body*:** After absorption, the toxicants enter the plasma fluid for distribution throughout the body. Distribution of toxicants depends on their ability to cross cell membranes and on their affinity to various body components [7].

***C. Metabolism of Toxicants*:** Metabolism involves processes of biotransforming the foreign substances to become more active and toxic or passive and detoxified. Metabolism of toxicants also enhances their elimination by making them more water-soluble. It is therefore part of the defense mechanisms of the body for toxic substances [7].

***D. Excretion of Toxicants*:** The kidney is perhaps the most important organ for the excretion of xenobiotics because more chemicals are eliminated from the body by this route than by any other. Other routes of excretion of toxicants include urinary system, lung, feces, gastrointestinal tract and breast milk [7].

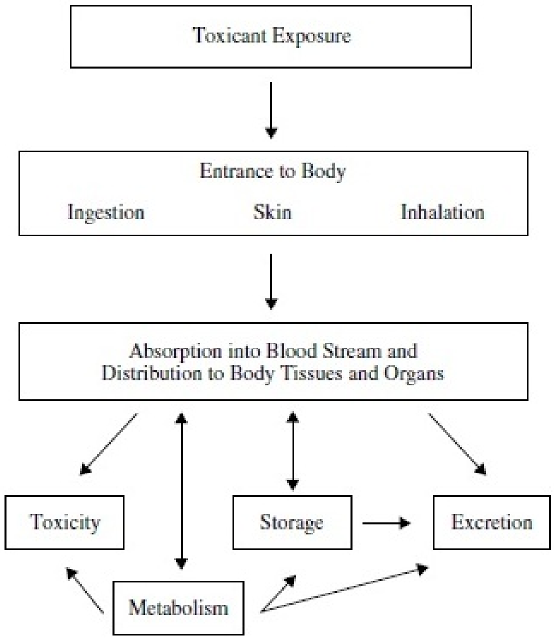

FIGURE 4: Fate and effect of toxicants in the body [2]

VII. SYNERGISTIC EFFECT OF TOXICANT

Metabolism of toxicants can make them even more poisonous when they combine with other substances or when they are transformed to different forms. Synergistic effect occurs when the combined effects of two chemicals are much greater than the sum of the effects of each given alone (example: 2 + 2 = 20). For example, both carbon tetrachloride and ethanol are hepatotoxic compounds, but together they produce more liver injury than the mathematical sum [9].

VIII. FATE AND TRANSPORT OF ENVIRONMENTAL TOXICANTS

A. Toxicant Persistence

Many abiotic and biotic processes exist in nature that degrades toxicants [3]. Many chemicals pose minimal hazard simply because of their limited life span in the environment. Insecticides such as PCBs are persistent and do not break down easily, and they are still found in soil long time after they were last used [10].

B. Toxicant Transport

Toxicants that are bound to soil particles e.g. pesticides may be carried into streams with runoff. Pesticide drift for example may travel many miles in the wind, PCBs are carried thousands of miles from developed nations of the temperate zone up to the Arctic, where they are found in tissues of polar bears and seals [11].

IX. BIOACCUMULATION OF TOXICANTS AND THEIR EFFECT ON BIODIVERSITY

Toxicants residues in the environment build up in organisms and in food webs this is called bioaccumulation, for example DDT that is lipophillic is slowly metabolized, and has the tendency to bioaccumulate in adipose tissue. Bioaccumulation occurs if residues build up faster than the organism can break down or excrete [12].

If a predator eats organism that have toxicants residues in its tissues, the predator may suffer from greater exposure than the prey. Bald eagles and ospreys were brought to the brink of extinction because of the contamination of their food sources (fish). The residues built up with each link in the food chain until very high concentrations were present in these birds and this is called biomagnifications [12].

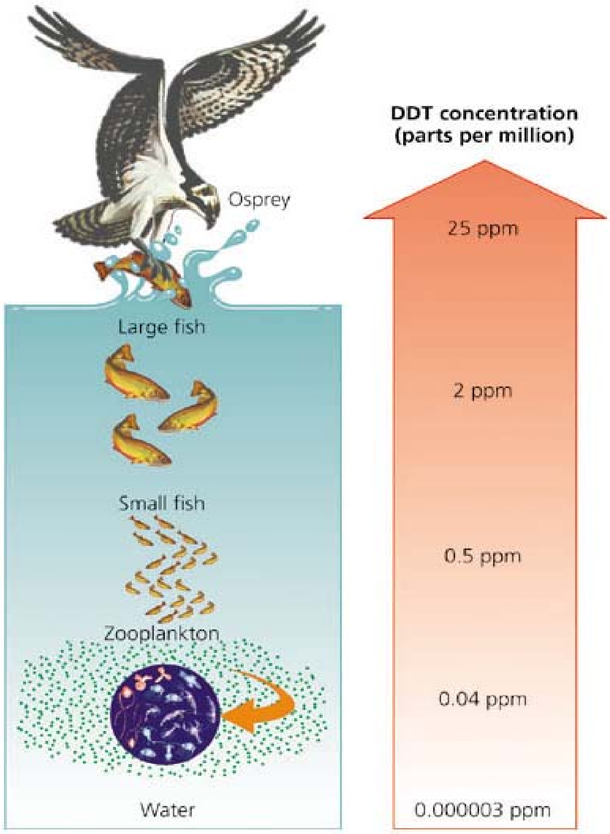

Figure 5: Stages in biomagnification [11]

X. EFFECTS OF ENVIRONMENTAL TOXICANTS

A. Effects on individuals

Toxicants can cause injury or death after exposure to plant or animal, they also can harm organisms by changing or killing something they required needs [13].

B. Effect at Population Level

Toxicants can affect more than just individuals. Decrease in population of predators due to toxic chemicals could lead to increase in numbers of its prey and vise versa and may result in disturbing of the population balance [13].

C. Community Effects of Toxicants

Effects can also occur on larger ecological scales, than that of the individual or population. For example, change in phytoplankton assemblage due to eutrophication can disrupt the Biological Oxygen Demand (BOD) of an aquatic community, thus affecting all organisms therein [14].

D. Effects at the Ecosystem Level

Pesticides and contaminants may also affect basic ecological processes like nutrient cycling or the formation of soil. For example, nitrogen cycling may be affected if pesticides impact the bacterial communities in soil. Carbon dioxide increased as the result of CFCs pollutants which lead to ozone layer depletion [15].

XI. ENVIRONMENTAL TOXICANTS AND BIODIVERSITY LOSS

Several attempts have been made to analyze the impacts of environmental toxicants particularly pollutants on wildlife. More recently, World Wildlife Fund has assessed the impacts on wildlife through a survey which identified effects on 1,300 species, including 11 mammals, 29 birds, 10 amphibians and 398 higher plants providing the most detailed survey to date [16]. Some toxicants and issues they raise in biodiversity threatening have been highlighted in Table 1 to 4:

TABLE 1: Example of Plant Species Threaten by Environmental Toxicants

Name	Note	Source
Blue green algae	*Nostoc* become endangered all over Europe due to air pollution	[17]
Lichens	*Lobaria pulmonaria*, *Leptogium burgessii* etc have their population declined due to wet acid deposition	[14]
Moses	*Grimmia pulvinata* become endangered from exposure to SO_2	[18]
Fungi	*Sarcodon imbricatus* was lost from insecticidal effect in soil	[17]
Flowering plants	*Larix europeaus* is sensitive to acute damage by ozone	[19]
	Eastern White Pine decline due to increased fluoride effluents from fertilizer industries in Alabama USA	[20]

TABLE 2: Some Freshwater and Marine Animals Threaten by Environmental Toxicants

Name	Note	Source
Snails	Developmental anomalies in marine gastropods exposed to tributyltin which is used as anti-fouling paint on ship hulls.	[21]
Fishes	Copper exposure in zebrafish led to loss of sensitivity	[22]
Water birds	Selenium effluents produced severe developmental effects in water birds in a created wetland in Central California	[23]
Marine mammals	Sea lions (*Zalophus californianus*) in Central California coast have increased cancer rates due to DDT and PCBs contamination	[24]

TABLE 3: Some Examples of Land Invertebrates Threatened by Environmental Toxicants

Name	Notes	Sources
Insects	Butterflies and moths population decline in polluted Atmosphere	[25]
	Wasp are particularly sensitive to SO_2 pollution	[26]
Arachnida	Research in Denmark linked decline in some spider species with high levels of SO_2	[27]

TABLE 4: Some Examples of land Vertebrates Threatened by Environmental Toxicants

Name	Note	Source
Birds	Osprey (*Pandion halietus)* decline is linked to secondary poisoning through fish	[8]
Amphibians	Salamander (*Ambystoma maculatum)* declines in New York due to effluents pollution of breeding pools	[28]
Reptiles	Alligators (*Alligator mississippiensis*) inhabiting a DDT-polluted lake in Florida have exhibited reproductive and developmental perturbations	[29]
Small mammals	Reduction in insect populations in polluted areas affect small birds and mammals such as mice	[30]

XII. Policies on Toxicants

In Nigeria, agency that took care of the prevention from production of toxicants includes National Agency for Food and Drug Administration and Control (NAFDAC) that regulate: food, additives, cosmetics, drugs, medical devices. Others include NESREA, SON and Federal Ministry Environmental.

A. International Policies on Toxicants

There is little or no effective regulation in most developing nations.

B. Stockholm Convention, 2001

International treaty to phase out 12 persistent organic pollutants (POPs) dubbed “the dirty dozen”. It came into force in 2004. It has 179 signatories, including the European Union (Shanky, 2013).

XIII. PREVENTION OF IMPACTS OF ENVIRONMENTAL TOXICANTS

Effects of environmental toxicants are always a consequence of exposure and no matter what their effect is, without exposure, no toxic effect will occur. There are possible actions available to reduce exposure. These actions range from banning from production and use of the toxicant in question, through measures to restrict exposure, to measures to restrict effect [13]. Other ways to follow in curving effects of environmental toxicants include:

- Monitoring, public education and regulation of industry could together decrease our exposure to toxicants.
- Endocrine disruption and other novel threats most be actively researched.
- Regulatory agencies should do their best in assessing chemicals accurately and fairly.

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