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Imbalance due to Pesticide Contamination in Different Ecosystems

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ABSTRACT: Pests cause a lot of damage to crops and thus are being killed by the application of pesticides. Various pesticides have been used for crop protection over the decades. The pesticides cause damage not only to crops but to the environment and other ecosytems as well. Excessive use of pesticides may also lead to the destruction of biodiversity. Many birds, aquatic organisms and animals are under the threat of harmful pesticides for their survival. Pesticides are a concern for sustainability of environment and global stability. This reveiw intends to discuss the various adverse impacts on soil and water. The review also discusses the methods to eradicate the use of pesticides and finally it looks forward towards the future impacts of the pesticide use the future of the world after eradicating pesticides.

Keywords: Pesticides, Environment, biodiversity, impact

I. INTRODUCTION

Insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others are various forms of pesticides used to kill different pesticides. organochlorine (OC) insecticides were used successfully in controlling a number of diseases like malaria and typhus, and subsequently were banned or restricted after the 1960s in most of the technologically advanced countries. The introduction of organophosphate (OP) insecticides in the 1960s, carbamates in 1970s and pyrethroids in 1980s and the introduction of herbicides and fungicides in the 1970s–1980s have tremendesouly increased agricultural input by killing various pests. The pesticides do not only kill the target organisms but to the non target ones and their rampant use has played havoc with human and other life forms.

Examining soil and water biological communities utilizing a microbial nature approach, which investigations the decent variety and working of microbial groups, can help in assessing the effect of ecological stressors, for example, xenobiotics. Truth be told, soil and water microorganisms assume a vital part in keeping up biological system natural quality. For example, the capacity of soil and water to recuperate from substance tainting is fundamentally subject to the nearness of a microbial group with the capacity to evacuate it. Moreover the microbial group attributes of a biological community can demonstrate changes in asset accessibility and the nearness of contamination. Thusly, the microbial group speaks to a critical key to understanding the effects of natural and anthropogenic factors on biological communities.

The expanding adulteration of freshwater biological systems with various diffuse source manufactured pesticides is perceived as a standout amongst the most critical stressors to freshwater environments [1]. Especially, the utilization of manufactured pyrethroid bug sprays has raised much worry because of their high harmfulness to non-target freshwater fauna [2,3]. Surface water bodies are tainted with numerous anthropogenic harmful chemicals that can influence their common groups. It is important to evaluate the impacts of these chemicals with a specific end goal to preserve oceanic biological communities. Among the anthropogenic chemicals, pesticides may cause the most difficult issues since they are composed particularly to execute life forms (both the harmful target life forms and other non-target ones) and they are discharged into the common habitat purposefully. It has been broadly recorded that pesticide fixations in the indigenous habitat are regularly sufficiently high to murder certain living beings [4,5] and influence the structure and capacity of normal groups [6,7]. Pesticides apply their effects at numerous levels including atoms, tissues, organs, people, populaces and groups and an assortment of ecotoxicological tests have been intended to survey these impacts [8]. Notwithstanding, this evaluation is ruined by the way that characteristic environments are differing and the impacts are complicated.

A. Production and usage of pesticides in India

The generation of pesticides began in India in 1952 with the foundation of a plant for the creation of BHC close Calcutta, and India is currently the second biggest maker of pesticides in Asia after China and positions twelfth universally [9]. There has been an unfaltering development in the generation of specialized review pesticides in India, from 5,000 metric tons in 1958 to 102,240 metric tons in 1998. In 1996–97 the interest for pesticides regarding esteem was evaluated to associate with Rs. 22 billion (USD 0.5 billion), which is around 2% of the aggregate world market.

The example of pesticide utilization in India is unique in relation to that for the world all in all. As can be found in Figure 1, in India 76% of the pesticide utilized is bug spray, as against 44% all inclusive [9]. The utilization of herbicides and fungicides is correspondingly less overwhelming. The primary utilization of pesticides in India is for cotton crops (45%), trailed by paddy and wheat.

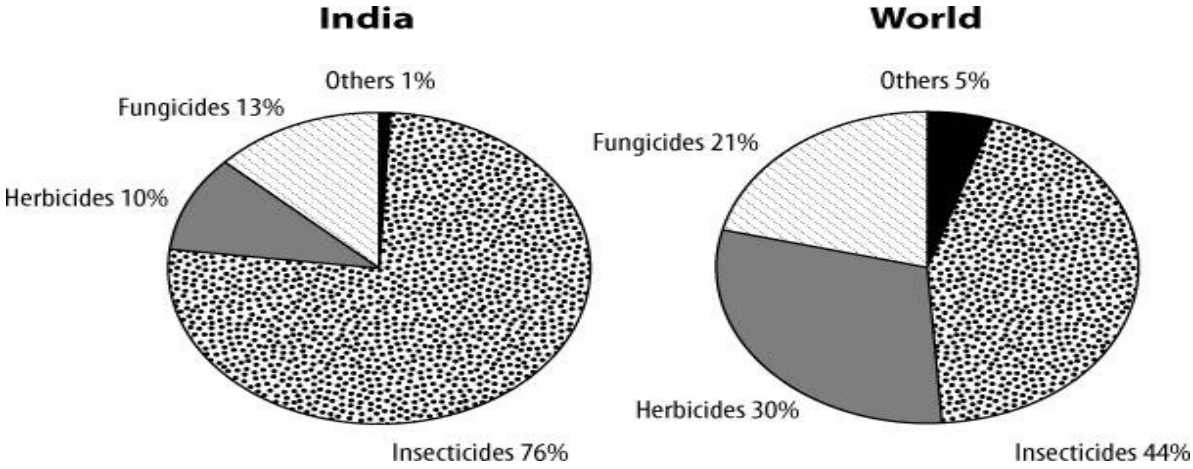


Fig. 1. Consumption pattern of pesticides [69].

B. Surface water contamination

Pesticides can reach surface water through overflow from treated plants and soil. Pollution of water by pesticides is far reaching. The after effects of a thorough arrangement of concentrates done by the U.S. Land Survey (USGS) on real stream bowls the nation over in the ahead of schedule to mid-90s yielded startling outcomes. In excess of 90 percent of water and fish tests from all streams contained, at least one regularly, a few pesticides [10]. Pesticides were found in all examples from real waterways with blended horticultural and urban land utilize impacts and 99 percent of tests of urban streams [11]. The USGS likewise found that centralizations of bug sprays in urban streams ordinarily surpassed rules for insurance of oceanic life [12]. Twenty three pesticides were distinguished in conduits in the Puget Sound Basin, including 17 herbicides. As per USGS, a bigger number of pesticides were recognized in urban streams than in agrarian streams [13]. The herbicides 2, 4-D, diuron, and prometon, and the bug sprays chlorpyrifos and diazinon, all ordinarily utilized by urban property holders were among the 21 pesticides distinguished frequently in surface and ground water the country over ([14]. Trifluralin and 2,4-D were found in water tests gathered in 19 out of the 20 waterway bowls considered [15,16,17,18]. The USGS likewise found that convergences of bug sprays in urban streams ordinarily surpassed rules for security of sea-going life [12]. As per USGS, "when all is said in done a bigger number of pesticides were distinguished in urban streams than in rural streams", [11]. The herbicide 2, 4-D was the most ordinarily discovered pesticide, distinguished in 12 out of 13 streams. The bug spray diazinon, and the weed-executioners dichlobenil, diuron, triclopyr, and glyphosate were recognized likewise in Puget Sound bowl streams. Both diazinon and diuron were found at levels surpassing focuses prescribed by the National Academy of Sciences for the security of sea-going life [11].

C. Ground water contamination

Groundwater contamination because of pesticides is an overall issue. As per the USGS, no less than 143 unique pesticides and 21 change items have been found in ground water, including pesticides from each significant synthetic class. In the course of recent decades, recognitions have been found in the ground water of in excess of 43 states [19]. Amid one overview in India, 58% of drinking water tests drawn from different hand pumps and wells around Bhopal were polluted with Organo Chlorine pesticides over the EPA benchmarks [20].

When ground water is dirtied with poisonous chemicals, it might take numerous years for the pollution to disseminate or be tidied up. Cleanup may likewise be expensive and complex, if certainly feasible [19,21,22] .Soil tainting countless items (TPs) from an extensive variety of pesticides have been archived [23,24,25]. Very few of all conceivable pesticide TPs have been checked in soil, demonstrating that there is a squeezing requirement for more examinations in this field. Persistency and development of these pesticides and their TPs are dictated by a few parameters, for example, water dissolvability, soil-sorption consistent (Koc), the octanol/water segment coefficient (Kow), and half-life in soil (DT 50). Pesticides and TPs could be gathered into: (a) Hydrophobic, steady, and bioaccumulable pesticides that are will undoubtedly soil. Pesticides that display such conduct incorporate the organochlorine DDT, endosulfan, endrin, heptachlor, lindane and their TPs. A large portion of them are currently restricted in horticulture however their deposits are as yet present. (b) Polar pesticides are spoken to essentially by herbicides yet they incorporate additionally carbamates, fungicides and some organophosphorus bug spray TPs. They can be moved from soil by spillover and draining, along these lines constituting an issue for the supply of drinking water to the populace. The most inquired about pesticide TPs in soil are without a doubt those from herbicides. A few metabolic pathways have been proposed, including change through hydrolysis, methylation, and ring cleavage that create a few poisonous phenolic mixes. The pesticides and their TPs are held by soils to various degrees, contingent upon the cooperations amongst soil and pesticide properties. The most persuasive soil trademark is the natural issue content. The bigger the natural issue content, the more noteworthy the adsorption of pesticides and TPs. The limit of the dirt to hold emphatically charged particles in an interchangeable frame is critical with paraquat and different pesticides that are decidedly charged. Solid mineral corrosive is required for separating these chemicals, with no diagnostic change or concentrate detailed as of late. Soil pH is additionally of some significance. Adsorption increments with diminishing soil pH for ionizable pesticides (*e.g.* 2,4-D,2,4,5-T, picloram, and atrazine) [26].

D. Impact on soil fertility (advantageous soil microorganisms)

Overwhelming treatment of soil with pesticides can make populaces of valuable soil microorganisms decay. Abuse of compound manures and pesticides have consequences for the living beings that are like human abuse of anti-infection agents. Unpredictable utilization of chemicals may labor for a couple of years, yet after for a short time, there aren't sufficient valuable soil living beings to clutch the supplements" [27]. For instance, plants rely upon an assortment of soil microorganisms to change barometrical nitrogen into nitrates, which plants can utilize. Regular scene herbicides upset this procedure: triclopyr hinders soil microscopic organisms that change salts into nitrite [28] glyphosate diminishes the development and movement of free-living nitrogen-settling microorganisms in soil [29] and 2,4-D lessens nitrogen obsession by the microbes that live on the underlying foundations of bean plants [30,31] decreases the development and action of nitrogen-settling blue green growth [32,33] and represses the change of alkali into nitrates by soil microbes [34,35]. Mycorrhizal growths develop with the foundations of numerous plants and help in supplement take-up. These organisms can likewise be harmed by herbicides in the soil. One investigation found that oryzalin and trifluralin both repressed the development of specific types of mycorrhizal organisms [36]. Gathering has been appeared to be poisonous to mycorrhizal organisms in lab studies, and some harming impacts were seen at fixations lower than those found in soil following normal applications [37,38]. Triclopyr was additionally observed to be poisonous to a few types of mycorrhizal growths [37] and oxadiazon lessened the quantity of mycorrhizal parasitic spores [39].

E. Threats to Biodiversity

The threats associated with the use of uncontrolled use of pesticides cannot be overlooked. It is the need of the day to consider the pesticide impact on populations of aquatic and terrestrial plants, animals and birds. Buildup of pesticides in the food chains is of greatest worry as it directly affects the predators and raptors. But, indirectly, pesticides can also decrease the quantity of weeds, shrubs and insects on which higher orders feed. Spraying of insecticides, herbicides and fungicide have also been linked to declines in the population of rare species of animals and birds.

Pesticides enter the water via drift, by runoff, leaching through the soil or they may be applied directly into surface water in some cases such as for mosquitoes' control. Pesticide-contaminated water cause a great risk to aquatic form of life. It can affect aquatic plants, decrease dissolved oxygen in the water and can cause physiological and behavioural changes in fish populations.

In several studies, lawn care pesticides have been found in surface waters and water bodies such as ponds, streams and lakes. Pesticides which are applied to land drift to aquatic ecosystems and are toxic to fishes and non-target organisms. These pesticides are not only poisonous themselves but also interact with stressors which include harmful algal blooms. With the overuse of pesticides, a turn down in populations of different fish species is observed [40]. Aquatic animals are vulnerable to pesticides in three ways [41].

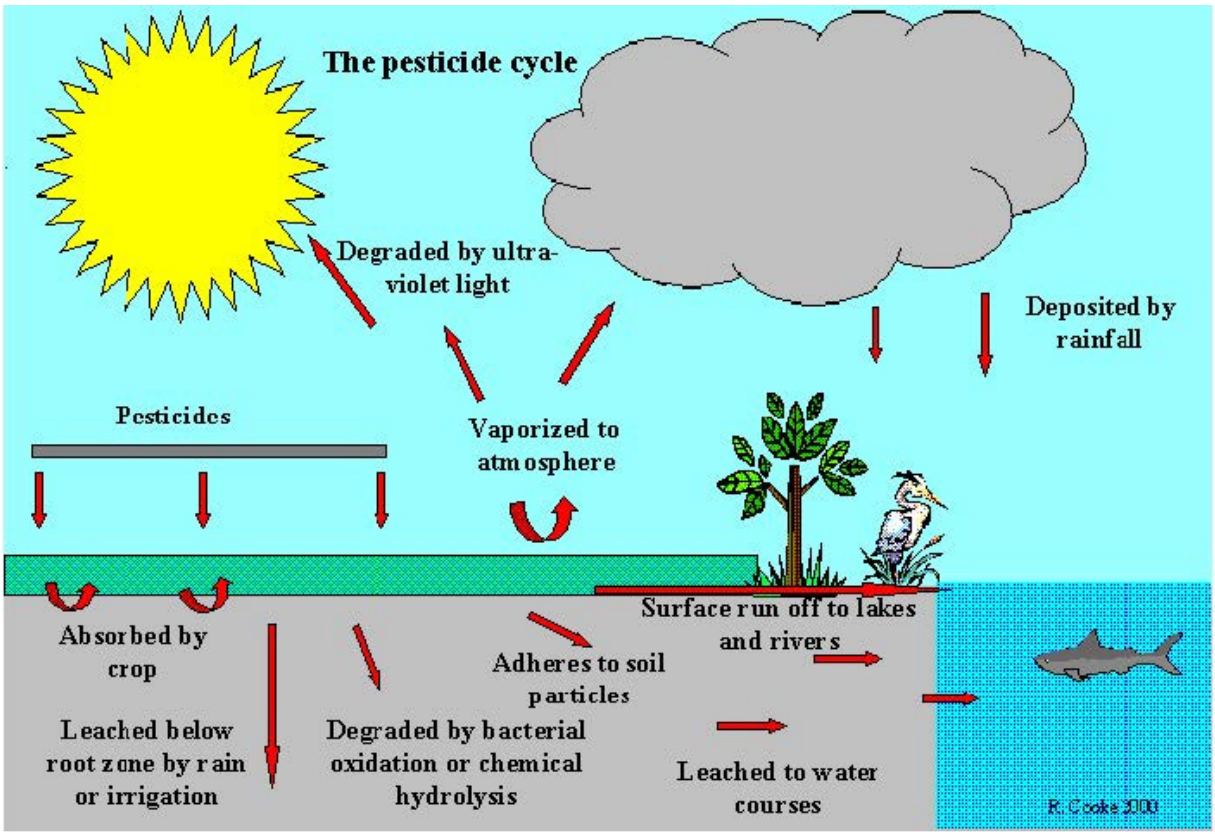
- Dermally : Direct absorption via skin
- Breathing : Uptake via gills during breathing
- Orally : Entry via drinking contaminated water

Around 80 % of the dissolved oxygen is given by the aquatic plants and it is vital for the sustenance of aquatic plants life. Killing of amphibian plants by the herbicides brings about definitely low O_2 levels and eventually prompts suffocation of fish and diminished fish efficiency [41]. For the most part, levels of pesticides are significantly higher in surface waters than groundwater presumably as a result of surface overflow from farmland and pollution by shower float [42]. Be that as it may, pesticides achieve underground through drainage of sullied surface water, dishonorable transfer and coincidental spills and spillages [43]. Oceanic biological systems are encountering impressive harm because of floating of pesticides into the lakes, lakes and waterways. Atrazine is lethal to some fish species and it likewise in a roundabout way influences the insusceptible arrangement of a few creatures of land and water [44,45]. Creatures of land and water are chiefly influenced by pesticides polluted surface waters, notwithstanding overexploitation and environment misfortune [46]. Carbaryl has been discovered dangerous for a few land and water proficient species, while, herbicide glyphosate is known to cause high mortality of tadpoles and adolescent frogs [47]. Small quantity of malathion have been appeared to change the wealth and creation of tiny fish and periphyton populace that subsequently influenced the development of frog tadpoles [48]. Besides, chlorpyrifos and endosulfan additionally make genuine harm creatures of land and water [49]. Dr. Hayes found that 10 % of male frogs brought up in atrazine-polluted water formed into females. Male frogs that were hereditarily male phenotypically created ovaries inside their testicles. They additionally built up the propensity to mate with different males and lay supportable eggs. The regenerative capability of oceanic living things additionally diminishes because of herbicide showering close weedy fi sh nurseries which in the long run decreases the measure of haven that is required by young fish to avoid predators [41].

F. Dangers to Terrestrial Biodiversity

Pesticide presentation can likewise cause sub-deadly consequences for earthbound plants notwithstanding killing non-target plants. Floating or volatilization of phenoxy herbicides can harm close-by trees and bushes [50]. Herbicide glyphosate builds vulnerability of plants to illnesses [51] and lessens seed quality [52]. Indeed, even low measurements of herbicides, sulfonylureas, sulphonamides and imidazolinones devastatingly affect the efficiency of nontarget crops, common plant groups and natural life [53]. Pesticides have not saved the earthly creature populaces. Populaces of benefi cial creepy crawlies, for example, honey bees and scarabs can signifi cantly decay by the utilization of expansive range bug sprays, for example, carbamates, organophosphates and pyrethroids. Creepy crawly populace has additionally been observed to be more noteworthy on natural homesteads contrasted with non-natural ones. Synergistic impacts of pyrethroids and triazole or imidazole fungicides are destructive to bumble bees. Neonicotinoids bug sprays, for example, clothianidin and imidacloprid are dangerous to honey bees. Imidacloprid even at low measurements adversely influences honey bee scavenging conduct not withstanding decreasing learning limit [54]. The best devastation wreaked by neonicotinoids was the sudden vanishing of bumble bees at the very beginning of the twenty-first century. This was a noteworthy worry to the nourishment business as 1/3 of the sustenance generation relies upon fertilization by honey bees. Nectar and wax got from business hives were accounted for to contain a blend of pesticides of which neonicotinoids shared a signifi cannot partition. Since 2006, every year, bumble bee populaces have dropped by 29– 36 %. Since pre-farming circumstances, 20– 25 % of the flying creature populaces have declined. One of the significant reasons for this monstrous decrease is the utilization of pesticides which was not known before 1962. Pesticide gathering in the tissues of fowl species prompts their passing. Bald eagle populaces in the USA declined basically in light of presentation to DDT and its metabolites [55]. Fungicides can in a roundabout way decrease flying creatures and warm blooded animal populaces by murdering worms on which they nourish. Granular types of pesticides are veiled as nourishment grains by feathered creatures. Organophosphate bug sprays are exceptionally poisonous to winged animals and they are known to have harmed raptors in the fi elds. Sublethal amounts of pesticides can influence the sensory system, causing behavioral changes [56].

Pesticides can be connected as fluid showers on the dirt or yield plant, might be consolidated or infused into the dirt or connected as granules or as a seed treatment. When they have achieved their objective territory, pesticides vanish by means of debasement, scattering, volatilisation or draining into surface water and groundwater; they might be taken up by plants or soil life forms or they may remain in the dirt [57]. The significant worry of pesticide abuse is their filtering into the dirt, which influences the microorganisms living in it. Soil abiding microorganisms help the plants in various routes, for example, supplement take-up; breakdown of natural issue and expanding soil fruitfulness. Yet, in a roundabout way they are additionally favorable to people as we vigorously rely upon plants. Sadly, pesticide abuse may have extreme results and a period may come when we would not have any a greater amount of these life forms and soil may debase. A few soil microorganisms are engaged with the fi xation of barometrical nitrogen to nitrates. Chlorothalonil and dinitrophenyl fungicides have been appeared to upset nitrifi cation and de-nitrifi cation microbes subordinate procedures [58]. The herbicide, triclopyr hinders soil microscopic organisms associated with the change of smelling salts into nitrite [59]. Glyphosate, a non-specific herbicide, diminishes the development and action of nitrogen-fi xing microorganisms in soil [60] while, 2,4-D hinders the change of smelling salts into nitrates did by the dirt microscopic organisms [61]. Herbicides likewise make impressive harm parasitic species in soil as pesticides trifl uralin and oryzalin both are known to restrain the development of advantageous mycorrhizal growths [36] that assistance in supplement take-up. Oxadiazon has been known to diminish the quantity of contagious spores [39] though triclopyr is dangerous to specific types of mycorrhizal organisms [37]. Night crawlers assume a signifi cannot part in the dirt biological community by going about as bioindicators of soil sullying and as models for soil poisonous quality testing. Night crawlers likewise add to soil ripeness. The bug sprays and additionally fungicides create neurotoxic impacts in worms and after a long haul presentation they are physiologically harmed [62].



The Pesticide Cycle;

Glyphosate and chlorpyrifos affect night crawlers at the cell level causing DNA harm. Glyphosates influence bolstering action and suitability of worms [63]. Goulson investigated the damages of neonicotinoids on condition and creature life. He revealed that as neonicotinoids tend to collect in the soil, in this manner, they can kill night crawlers, for example, *Eisenia foetida* species [64].

II. CONCLUSION

Pesticides have turned out to be an aid for the farmers and in addition individuals all around the globe by expanding farming yield and by giving endless advantages to society in a roundabout way. Be that as it may, the issue of perils postured by pesticides to human wellbeing and nature has raised worries about the security of pesticides. Despite the fact that we can't totally dispose of the perils related with pesticide utilize, yet we can go around them in one way or the other. Presentation to pesticides and henceforth the unsafe outcomes and bothersome impacts of this introduction can be limited by a few means, for example, elective editing techniques or by utilizing all around kept up showering types of gear. Generation of better, safe and condition well disposed pesticide details could decrease the hurtful impacts related with the pesticide use. In the event that the pesticides are utilized as a part of suitable amounts and utilized just when required or essential, at that point pesticide dangers can be limited. Thus, if a less harmful detailing or low measurements of a poisonous plan is utilized, the destruction can be controlled. As Paracelsus additionally once said "The right dose differentiates a poison from a remedy". There are organochlorines, which are utilized as pesticides. These pesticides are minimum biodegradable and their utilization is restricted in numerous nations. Other than this reality, organochlorines are exceedingly utilized as a part of numerous spots. This outcomes in genuine wellbeing dangers. Water contamination is on the ascent because of these pesticides, even at low fixation, these pesticides have genuine risk to the earth [65]. The lion's share of agriculturists is uninformed of the potential toxicities of pesticides. They have no data about sorts of pesticides, their level of harming, risks and security measures to be taken before utilization of those pesticides. Because of this reason, lethal and ecologically persevering chemicals are utilized to slaughter bothers which can likewise prompt purposeful, accidental or word related presentation. These mixes have long haul consequences for human wellbeing. Mindfulness ought to be orchestrated these agriculturists to decrease the employments of lethal pesticides [66]. In future synthetic pesticides can be utilized as a part of blend with regular medications and cures which result in more practical end of bugs and bugs. This blend guarantees ecological maintainability, as well as has differing applications in controlling of urban nuisances and obtrusive species [67]. Pesticides have additionally represented a genuine danger on organic trustworthiness of marine and oceanic biological systems. It is the need of time to coordinate the investigations of various orders including toxicology, natural science, populace science, group biology, preservation science and scene environment to see immediate and roundabout impacts of pesticides on the earth [68].

REFERENCES

[1]. Schwarzenbach, R.P., Escher, B.I., Fenner, K., Hofstetter, T.B., Johnson, C.A., von Gunten, U., Wehrli, B., 2006. The challenge of micropollutants in aquatic systems. *Science*, **313**, 1072–1077.

[2]. Schulz, R., 2004. Field studies on exposure, effects, and risk mitigation of aquatic nonpoint-source insecticide pollution: a review. Journal of Environment Quality 33, 419–448.

[3]. Kuivila, K.M., Hladik, M.L., Ingersoll, C.G., Kemble, N.E., Moran, P.W., Calhoun, D.L., Nowell, L.H., Gilliom, R.J., 2012. Occurrence and potential sources of pyrethroid insecticides in stream sediments from seven U.S. metropolitan areas. Environmental Science and Technology 46, 4297–4303.

[4]. Hatakayama, S., Shiraishi, H., Sugaya, Y., 1991. Monitoring of the overall pesticide toxicity of river water to aquatic organisms using a freshwater shrimp, Paratya compressa improvisa. *Chemosphere* **22**, 229-235.

[5]. Hatakayama, S., Fukushima, S., Kasai, F., Shiraishi, H., 1994. Assessment of herbivide effects on algal production in the Kokai River (Japan) using model stream and Selenastrum bioassay. *Ecotoxicology* **3**, 143-156.

[6]. Helgen, J.C., Larson, N.J., Anderson, R.L., 1988. Response of zooplankton and Chaoborus to temephos in a natural pond and in the laboratory. *Archives of Environmental Contamination and Toxicology,* **17**, 459-471.

[7]. Hatakeyama, S., Shiraishi, H., Kobayashi, N., 1990. Effects of aerial spraying of insecticides on nontarget mafrobenthos in a mountain stream. *Ecotoxicology and Environmental Safety*, **19**, 254-270.

[8]. Cairns Jr., J., Neiderlehner, B.R. (Eds.), 1985. Ecological Toxicity Testing. Lewis Publishers, Boca Raton, FL.

[9]. Mathur SC. (1999). Future of Indian pesticides industry in next millennium. Pesticide information 24(4): 9–23.

[10]. Kole RK, Banerjee H. and Bhattacharyya A. (2001). Monitoring of market fish samples for Endosulfan and Hexachlorocyclohexane residues in and around Calcutta. Bull Envirron Contam Toxicol 67: 554–559.

[11]. Bortleson G and Davis D 1987–1995. U.S. Geological Survey & Washington State Department of Ecology. Pesticides in selected small streams in the Puget Sound Basin: 1–4.

[12]. U.S. Geological Survey. (1999). The quality of our nation's waters – nutrients and pesticides. Circular 1225. Reston VA: USGS. http: //water.usgs.gov/pubs/circ/ circ1225/
[13]. US Department of the Interior. (1995). Pesticides in ground water: current understanding of distribution and major infl uences. U.S. Geological Survey. National Water Quality Assessment. Factsheet number FS-244-95.
[14]. U.S. Geological Survey (1998). National Water-Quality Assessment. Pesticide National Synthesis Project. Pesti-cides in surface and ground water of the United States; Summary of results of the National Water Quality Assessment Program. http: //water.wr.usgs.gov/pnsp/allsum/fi g02.gif.
[15]. Bevans HE, Lico MS and Lawrence SJ. (1998). Water quality in the Las Vegas Valley area and the Carson and Truckee Riverbasins, Nevada and California, 1992–96. Reston, VA: USGS.U.S. Geological Survey Circular 1170.
[16]. Fenelon JM. (1998). Water quality in the White River Basin, Indiana, 1992–96. Reston, VA: USGS. U.S. Geological Survey Circular 1150.
[17]. Levings GW, Healy DF, Richey SF and Carter LF. (1998). Water quality in the Rio Grande Valley, Colorado, New Mexico, and Texas, 1992–95. Reston, VA: USGS. U.S. Geological Survey Circular 1162.
[18]. Wall GR, Riva-Murray K and Phillips PJ. (1998). Water Quality in the Hudson River Basin, New York and adjacent states, 1992–95. Reston, VA: USGS. U.S. Geological Survey Circular 1165.
[19]. Waskom R. (1994). Best management practices for private well protection. Colorado State Univ. Cooperative Extension (August). http: //hermes.ecn.purdue. edu: 8001/cgi/convertwq?7488.
[20]. Kole RK and Bagchi MM. (1995). Pesticide residues in the aquatic environment and their possible ecological hazards. *J Inland Fish Soc India* **27**(2): 79–89.
[21]. O'Neil W and Raucher R. (1998). Groundwater public policyleafl et series #4: The costs of groundwater contamination. Wayzata, MN: Groundwater Policy Education Project. http: //www.dnr.state.wi.us/org/water/dwg/gw/costofgw.htm (Aug.)
[22]. US EPA. (2001). Source water protection practices bulletin: Managing small scale application of pesticides to prevent contamination of drinking water. Washington, DC: Offi ce of Water (July). EPA 816-F-01-031.
[23]. Barcelo' D, Hennion MC. (1997). Trace Determination of Pesticides and Their Degradation Products in Water, Elsevier, Amsterdam, The Netherlands: **3**.
[24]. Roberts TR. (1998). Metabolic Pathway of Agrochemicals. Part I. In: Herbicides and Plant Growth Regulators; The Royal Soc Chem Cambridge, UK,
[25]. Roberts TR and Hutson DH. (1999). Metabolic Pathway of Agrochemicals Part II. In: Insecticides and Fungicides. The Royal Soc Chem Cambridge, UK,
[26]. Andreu V, Pico' Y. (2004). Determination of pesticides and their degradation products in soil: critical review and comparison of methods. *Trends Anal Chemistry,* **23**(10–11): 772–789.
[27]. Savonen C. (1997). Soil microorganisms object of new OSU service. Good Fruit Grower. http: //www.goodfruit.com/archive/ 1995/6other.html.
[28]. Pell M, Stenberg B, and Torstensson L. (1998). Potential denitrification and nitrification tests for evaluation of pesticide effects in soil. *Ambio* **27**:
[29]. Santos A. and Flores M. (1995). Effects of glyphosate on nitrogen fixation of free-living heterotrophic bacteria. *Lett Appl Microbiol* **20**: 349–352.
[30]. Arias RN and Fabra PA. (1993). Effects of 2,4-dichlorophenoxyacetic acid on Rhizobium sp. growth and characterization of its transport. *Toxicol Lett.,* **68**: 267–273.
[31]. Fabra A, Duff ard R, and Evangelista DDA. (1997).Toxicity of 2,4-dichlorophenoxyacetic acid in pure culture. *Bull Environ Contam Toxicol.,* **59**: 645–652.
[32]. Singh JB and Singh S. (1989). Eff ect of 2,4-dichlorophenoxyacetic acid and maleic hydrazide on growth of bluegreen algae (cyanobacteria) Anabaena doliolum and *Anacystis nidulans*. *Sci. Cult.* **55**: 459–460.
[33]. Tözüm-Çalgan SRD and Sivaci-Güner S. (1993). Eff ects of 2,4-D and methylparathion on growth and nitrogen fi xation in cyanobacterium, Gloeocapsa. *Intern J Environ Stud* **23**: 307–311.
[34]. Frankenberger WT, Tabatabai MA (Jr) and Tabatabai MA. (1991). Factors affecting L-asparaginase activity in soils. *Biol. Fert. Soils* **11**: 1–5.
[35]. Martens DA and Bremner JM. (1993). Influence of herbicides on transformations of urea nitrogen in soil. *J Environ Sci Health B* **28**: 377–395.
[36]. Kelley WD and South DB. (1978). In vitro eff ects of selected herbicides on growth and mycorrhizal fungi. Weed Sci. Soc. America Meeting. Auburn University, Auburn, Alabama: 38.
[37]. Chakravarty P and Sidhu SS. (1987). Eff ects of glyphosate, hexazinone and triclopyr on in vitro growth of five species of ectomycorrhizal fungi. *Euro J For Path,* **17**: 204–210.
[38]. Estok D, Freedman B and Boyle D. (1989). Effects of the herbicides 2,4-D, glyphosate, hexazinone, and triclopyr on the growth of three species of ectomycorrhizal fungi. *Bull Environ Contam Toxicol.,* **42**: 835–839.
[39]. MoormanTB. (1989). A review of pesticide eff ects on microorganisms and microbial processes related to soil fertility. *Journal Prod. Agric.,* **2**(1): 14–23.
[40]. Scholz NL, Fleishman E, Brown L, Werner I, Johnson ML, Brooks ML, Mitchelmore CL (2012). A perspective on modern pesticides, pelagic fish declines, and unknown ecological resilience in highly managed ecosystems. *Bioscience,* **62**(4): 428–434.
[41]. Helfrich LA, Weigmann DL, Hipkins P, Stinson ER (2009). Pesticides and aquatic animals: a guide to reducing impacts on aquatic systems. In: Virginia Polytechnic Institute and State University. Available from https://pubs.ext.vt.edu/420/420-013/420-013.html . Accessed Jan 17, 2015.

[42]. Anon (1993). The environmental effects of pesticide drift, Peterborough: English Nature. 9–7. Benefits of pesticides and crop protection chemicals. In: Crop life America. Available from http://www.croplifeamerica.org/crop-protection/benefi ts.
[43]. Pesticides in Groundwater (2014). In: The USGS Water Science School. Available from http:// water.usgs.gov/edu/pesticidesgw.html . Accessed Dec 17, 2014.
[44]. Forson DD, Storfer A (2006). Atrazine increases Ranavirus susceptibility in the tiger salamander (*Ambystoma tigrinum*). *Ecol Appl* **16**: 2325–2332.
[45]. Rohr JR, Schotthoefer AM, Raffel TR, Carrick HJ, Halstead N, Hoverman JT, Johnson CM, Johnson LB, Lieske C, Piwoni MD, Schoff PK, Beasley VR (2008). Agrochemicals increase trematode infections in a declining amphibian species. Nature 455:1235–1239.
[46]. The Asian Amphibian Crisis (2009). In: IUCN. Available from http://www.iucn.org/about/union/secretariat/offices/asia/regio nal_activities/asian_amphibian_crisis/ . Accessed Dec 19, 2014.
[47]. Relyea RA (2005). The lethal impact of roundup on aquatic and terrestrial amphibians. Ecol Appl 15:1118–1124.
[48]. Relyea RA, Hoverman JT (2008). Interactive effects of predators and a pesticide on aquatic communities. Oikos **117**: 1647–1658.
[49]. Sparling DW, Feller GM (2009). Toxicity of two insecticides to California, USA, anurans and its relevance to declining amphibian populations. *Environ Toxicol Chem* **28**(8): 1696–1703.
[50]. Dreistadt SH, Clark JK, Flint ML (1994). Pests of landscape trees and shrubs. An integrated pest management guide. University of California Division of Agriculture and Natural Resources. Publication No. 3359.
[51]. Brammall RA, Higgins VJ (1988). The effect of glyphosate on resistance of tomato to Fusarium crown and root rot disease and on the formation of host structural defensive barriers. *Can J Bot.,* **66**: 1547–1555.
[52]. Locke D, Landivar JA, Moseley D (1995). The effects of rate and timing of glyphosate applications of defoliation efficiency, regrowth inhibition, lint yield, fiber quality and seed quality. *Proc Beltwide Cotton Conf.* **2**:1088–1090.
[53]. Fletcher JS, Pfl eeger TG, Ratsch HC (1993). Potential environmental risks associated with the new sulfonylurea herbicides. *Environ Sci Technol.,* **27**: 2250–2252.
[54]. Decourtye A, Lacassie E, Pham-Delègue MH (2003). Learning performances of honeybees (*Apis mellifera* L.) are differentially affected by imidacloprid according to the season. *Pest Manag Sci.,* **59**: 269–278.
[55]. Liroff RA (2000). Balancing risks of DDT and malaria in the global POPs treaty. Pestic Safety News **4**: 3.
[56]. Pesticides reduce biodiversity (June 2010). *Pesticides News* **88**: 4–7.
[57]. Hayo MG, Werf VD (1996). Assessing the impact of pesticides on the environment. *Agric Ecosyst Environ* **60**: 81–96.
[58]. Lang M, Cai Z (2009). Effects of chlorothalonil and carbendazim on nitrifi cation and denitrifi cation in soils. *J Environ Sci* **21**: 458–467.
[59]. Pell M, Stenberg B, Torstensson L (1998). Potential denitrifi cation and nitrifi cation tests for evaluation of pesticide effects in soil. *Ambio* **27**: 24–28.
[60]. Santos A, Flores M (1995). Effects of glyphosate on nitrogen fi xation of free-living heterotrophic bacteria. *Lett Appl Microbiol* **20**: 349–352.
[61]. Frankenberger WT, Tabatabai MA Jr, Tabatabai MA (1991) Factors affecting L-asparaginase activity in soils. *Biol Fert Soils,* **11**: 1–5.
[62]. Schreck E, Geret F, Gontier L, Treilhou M (2008) Neurotoxic effect and metabolic responses induced by a mixture of six pesticides on the earthworm *Aporrectodea caliginosa nocturna. Chemosphere,* **71**(10): 1832–1839.
[63]. Casabé N, Piola L, Fuchs J, Oneto ML, Pamparato L, Basack S, Giménez R, Massaro R, Papa JC, Kesten E (2007) Ecotoxicological assessment of the effects of glyphosate and chlorpyrifos in an Argentine soya field. *J Soils Sedim* **7**: 232–239.
[64]. Goulson DJ (2013) An overview of the environmental risks posed by neonicotinoid insecticides. *J Appl Ecol.,* **50**: 977. doi: 10.1111/1365-2664.12111.
[65]. Agrawal A, Pandey RS, Sharma B (2010) Water pollution with special reference to pesticide contamination in India. *J Water Res Prot* **2**(5): 432–448.
[66]. Sharma DR, Thapa RB, Manandhar HK, Shrestha SM, Pradhan SB (2012). Use of pesticides in Nepal and impacts on human health and environment. *J Agric Environ* **13**: 67–72.
[67]. Gentz MC, Murdoch G, King GF (2010). Tandem use of selective insecticides and natural enemies for effective, reduced-risk pest management. *Biol Control* **52**(3): 208–215.
[68]. Macneale KH, Kiffney PM, Scholz NL (2010). Pesticides, aquatic food webs, and the conservation of Pacific salmon. *Front Ecol Environ* **8**: 475–482.
[69]. Aktar, W., Sengupta, D., & Chowdhury, A. (2009). Impact of pesticides use in agriculture: their benefits and hazards. *Interdisciplinary toxicology*, **2**(1), 1-12.