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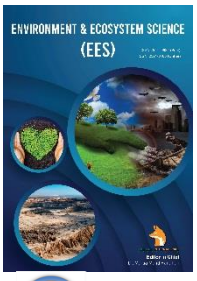

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REVIEW ARTICLE

PESTICIDE USE AND ITS IMPACTS ON HUMAN HEALTH AND ENVIRONMENT

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ABSTRACT

Every lay farmer as well the commercial growers use chemical pesticides to kill pests and weeds and to get rid of diseases in their farm with aim of increasing production. Though the use of pesticides has some advantages of increase in yield, its haphazard and excessive use also create a serious impact on the environmental components and human health. The present scenario of pesticide use doesn't seem to be satisfactory, so-called safe pesticides are also showing their ill effects in the long run and the problems such as bio-accumulation, bio-magnification are being magnified day after day. Almost all the corners of the earth and organisms living in it and those who are yet to be born have already been affected by so-called boons to pest control. This study attempts to study the present pesticides use scenario of Nepal and also the ill-effects of pesticides on human health as well as on the environment. The relevant data and information were collected from the thorough study of the journal articles, research papers, reports and various literatures. This paper pleads and sensitizes the readers to get directed toward more holistic, sustainable, natural and safe production and management practices.

KEYWORDS

Agriculture, Chemicals, Deaths, Nepal, Poisons.

1. INTRODUCTION

Pesticides are chemical compounds that are used to kill pests, including insects, rodents, fungi and unwanted plants (weeds). Pesticides are used in public health to kill vectors of disease, such as mosquitoes, and in agriculture, to kill pests that damage crops. The term pesticide includes all of the following: herbicide, insecticides nematicide, molluscicide, piscicide, avicide, rodenticide, bactericide, insect repellent, animal repellent, antimicrobial, and fungicide. It has been decades since the pesticide issue has been beautifully raised by Rachel Carson in her explosive best seller book Silent Spring (Carson, 2002). Since then many debates have been bursting out on this issue realizing that relying solely on the chemical control method is slowly leading towards a poisonous and dangerous world. Also, Masanobu Fukuoka has perfectly blended spirituality and agriculture in his book one straw revolution giving principles of natural farming which suggests and strongly stresses on not inputting any external chemical compounds in any names to the cropping system (Fukuoka, 2009).

Chemical compounds exploited blindly are bound to cause inevitable harm on both biotic and abiotic components of nature; they not only cause damage to the targeted organisms but also to all other non-targeted organisms either directly or indirectly (Carson, 2002). Out of 2.5 million tons of pesticides applied to the crops, less than 0.1% finds its way up to their target pests and the remaining more than 99.9% of pesticides applied are thus poured into the environment where they are bound to adversely affect public health and beneficial biota and contaminate soil, water and the ecosystem (Pimentel, 1995). Only 25% of the pesticides produced worldwide are used in developing countries, but they experience 99% of the total deaths. The reasons for this are intense and unsafe use of pesticides, and weak regulatory, health and education systems in developing countries (Vaagt, 2002). DDT was identified as a potential pesticide by Paul Herman Muller in 1939, for which he was awarded with Nobel Prize (Dhital et al., 2015).

Nepal too didn't remain away from this wave, during the 1950s, DDT was introduced for malaria eradication program which was later imported by the Government of Nepal. Following that, other pesticides like Lindane and Pyridine were imported for the same purpose. Gradually, new kinds of pesticides from organophosphates and carbamates group were also introduced. Till now pesticides in 169 common name and 3035 commercial names have been registered in different ten groups including botanical and biological; and 24 pesticides have been banned by Nepal Government so far, namely: Chlordane, DDT, Endrin, Aldrin, Dieldrin, Toxaphen, Organomercury fungicide, Lindane, BHC, Phosphamidon, Methyl parathion, Heptachlor, Monocrotophos, Endosulphan, Mirex, Phorate, Carbaryl, Dichlorvus, Triozophos, Benomyl, Carbosulphan, Dichofol, Carbofuran, Aluminium phosphide (MOALD, 2020). Even though the government doesn't seem to be serious in implementing it, farmers are still found to be using banned pesticides. Because of the porous borders with India farmers have easy access to those pesticides in the Indian market.

In Nepal two ways of pesticide residue analysis are used, namely mass chromatography and Rapid Bioassay of Pesticide Residue, only organophosphate and Carbamate group of insecticide were tested in the

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later one which is much extensively used method (PQPMC, 2018). Misuse of pesticides is common in Nepal. Unregistered and illegal products and open-air sales, sales of banned products, cases of decanting and reweighing, fake pest control products, sales of expired products with modified expiry date are among the misuse cases that have been reported in Nepal (Sharma et al., 2012). These types of misuse of pesticides have negative impacts on human health, environment, ecosystem, beneficial microorganisms, wildlife, beneficial insects, aquatic animals etc. Also, the phenomenon and cases like bio-accumulation, bio-magnification, pesticide-contamination, residue retention, pesticide resistance, secondary pest outbreak, co-evolution, un-intended accidents, industrial chemical explosions and so on caused by the excessive and undisciplined use of pesticides cannot be overlooked.

2. Objective

The objective of this article review is to get a clear picture of the effect of indiscriminate use of chemicals in environmental health and human health and make an attempt to sensitize the readers to take judicial actions to make this earth a better place to reside.

3. Methodology

The information and data were collected from the secondary sources during the preparation of this manuscript. Research articles, books, reports, news, and other required materials were collected from various e-sources including Google, Google Scholar, Research Gate, Directory of Open Access Journal, etc. and were thoroughly reviewed and extensive evaluation was done for the preparation of the manuscript.

4. Discussion

4.1 Pesticides use scenario of Nepal

Pesticides are mostly used in agriculture to increase the yield, improve quality and for the increment of storage life of the agricultural products. In Nepal, import and formulations of different forms of pesticides are increasing day by day. In the fiscal year 2017/18, the annual import of the pesticides in Nepal was reported 632.41 tones active ingredient (a.i) which was worth NRs. 83,57,80,968 ($7,023,369.48) (PQPMC, 2018). Some researchers reported that there is a linear trend in pesticide import in Nepal and an annual increase in pesticide import is 27.16 tones (Kalauni and Joshi, 2019). A study conducted by Plant Protection Directorate (PPD) stated the national average consumption of pesticides as 396 gram a.i/ha which is higher than 142 gram a.i/ha as reported by IUCN in 1955 (PPD, 2014). However, the amount is less than the world average consumption of 0.5 kg a.i/ha. Similarly, the study also suggested that the amount of pesticides used in high hill, hill, terai and valley is 0.085 a.i kg/ha (4%), 0.314 a.i kg/ha (20%), 0.0995 a.i kg/ha (59%) and 0.470 a.i kg/ha (17%) respectively (PPD, 2014). National survey on pesticide consumption statistics in Nepal showed that the highest pesticides used in vegetables (89.0%) followed by cereals (7.5%), cash crops (2.5%) and pulses and fruits (0.5% each) (PPD, 2014).

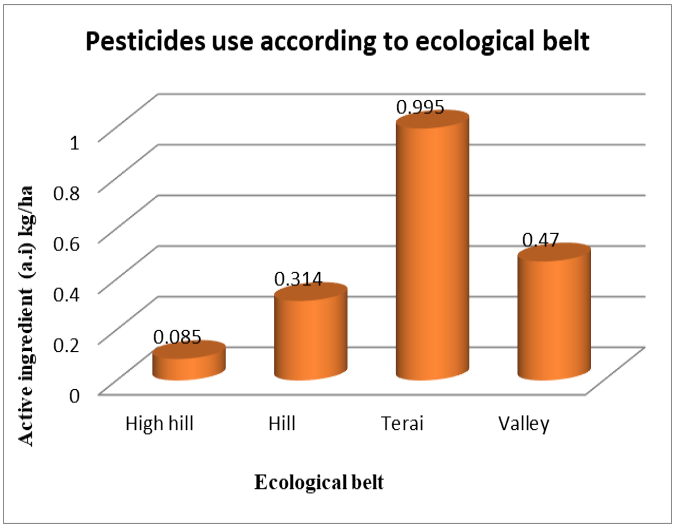

Figure 1: Pesticide use according to ecological belt (Source: Plant Protection Directorate (PPD, 2014)

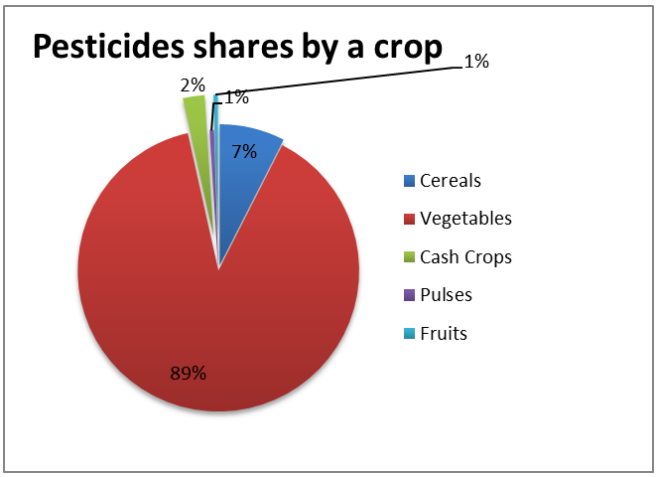

Figure 2: Pesticides shares by a crop (Source: Plant Protection Directorate (PPD, 2014)

4.2 Benefits of Pesticides use

Pesticides have both beneficial and harmful effects on the people and the environment. The primary benefit of using pesticides is killing of insect pests that feed on crops. It has been estimated that about 40% of the agriculture produce is lost worldwide due to disease, pest and weeds (Mahmood et al., 2016). Weeds infestation during crop establishment stage accounts for a reduction of 40% in yield (Aktar et al., 2009). Thus, pesticides provide both economic and labor benefits to the people. Pesticides also help to prevent diseases outbreaks by controlling rodents and insects' vector and many insect-born diseases such as encephalitis, yellow fever, bubonic plague, typhoid fever, typhus, Rocky Mountain spotted fever etc. have been kept in control by using pesticides (Mahmood et al., 2016).

4.3 Impacts of Pesticides in the environment

Excessive and uncontrolled use of pesticides can contaminate soil, water, turf and other vegetation. Pesticides can be toxic to other animals such as birds, fish, bees, beneficial insects as well as non-target plants and animals.

4.3.1 Surface and ground-water contamination

Pesticides can reach the water sources through runoff and leaching from the agriculture fields. The contamination of water sources is found in every place of the world. A study done by US Geological Survey (USGS) on major river basins across the US in the early to mid-90s reported several pesticides residues in more than 90% of water and fish samples (Kole et al., 2001). According to USGS, urban streams contained more pesticides compared to agricultural streams (Aktar et al., 2009). A study done by the UK government showed that pesticide concentrations exceeded those allowable for drinking water in some samples of river water and ground-water. There are four major routes through which pesticides can reach the water sources; drift outside of the intended area during spraying, or percolate, or leach through the soil, through runoff, or maybe spilled accidentally (States of Jersey, 2007).

The USGS reported 143 different pesticides and 21 transformation products (TPs) of every major class (Aktar et al., 2009). A survey done in India reported the presence of organochlorine pesticides in 58% of drinking water samples drawn from hand pumps and wells around Bhopal (Kole and Bagchi, 1995). Cleanup of ground-water contamination is very costly and complex, also somewhat impossible too (Aktar et al., 2009).

4.3.2 Soil contamination

Pesticides have a large number of transformation products (TPs) and the persistency and movement of these pesticides and their TPs are determined by parameters such as water solubility, soil-sorption constant (K_{oc}), the Octane/water partition coefficient (K_{ow}), and half-life in soil (DT_{50}) (Aktar et al., 2009). The most important characteristic of soil, related to pesticide absorption is organic matter content. The organic matter content is directly proportional to the adsorption of pesticides and TPs (Aktar et al., 2009). Pesticides such as Endrin, Endosulfan, Heptachlor, Lindane, Organochlorine DDT and their TPs are banned in agriculture but their residues are still found in soil (Aktar et al., 2009). The heavy application of pesticides in soil declines the population of beneficial soil microorganisms. Indiscriminate use of chemicals might increase yield for

some years but after a while, it will be harmful to soil microorganisms (Savonen, 1997). Soil microorganism helps to transform atmospheric nitrogen into nitrates which plants can use but some herbicides disrupt the process. Triclopyr inhibits the transformation of ammonia into nitrite by killing soil bacteria, glyphosate hampers the growth and activity of free-living nitrogen-fixing bacteria in soil and 2,4-dichlorophenoxyacetic acid (2,4-D) reduces nitrogen fixation (Pell et al., 1998; Santos and Flores, 1995; Arias and de Peretti, 1993).

4.3.3 Contamination of air and impacts on non-target vegetation

Pesticides can drift or volatilize from the sprayed area and can contaminate the atmosphere, soil, water sources and non-target vegetation. A study reported 80-90% of applied pesticides can be volatilized within a few days of application and can spread up to several hundred miles (Majewski, 2019). According to USGS, pesticides have been detected in the atmosphere in all sampled areas of the USA (Savonen, 1997). Herbicides are used to kill unnecessary weeds in the field however many ester-formulation herbicides volatilize and cause damage to the plants with vapors (Straathof, 1986). 2,4-D and other Phenoxy herbicides are found to injure nearby vegetation if they drift onto the leaves (Dreistadt, 2016). Glyphosate can severely reduce seed quality and increase the plant's susceptibility to diseases (Locke et al., 1995; Brammall and Higgins, 1988). It has been found that the volatilization of only 1% of applied Clopyralid is enough to damage non-target plants (Aktar et al., 2009).

4.3.4 Impacts on non-target organisms

Haphazard application of pesticides can also harm plants and animals ranging from beneficial soil microorganisms and insects, non-target plants, fish, birds, and other wildlife. Chloropyrifos has been found to kill fishes in waterways near treated fields in the USA (U.S. EPA, 2000). Trifluralin is found to be highly toxic to both cold and warm water fish (U.S. EPA, 1996). Glyphosate can cause sub-lethal effects such as labored breathing increases the fish's chances of being eaten (Liong et al., 1988). 2, 4-D herbicides caused physiological stress responses in salmon and also reduces the food-gathering abilities of rainbow trout (Little et al., 1990).

Pesticides can kill bees and causes decline in pollination because of colony collapse disorder caused by pesticides; in which worker bees abruptly disappear from beehive (Wells, 2007). Pollinators such as bees, birds and bats affect 35 percent of the world's crop production, increasing the output of 87 of the leading food crops worldwide (University of California - Berkeley, 2006). Some pesticides can bio-accumulate in the body of organisms that consume it over time and is transferred to trophic levels in the food chain. Exposure of eggs to 2, 4-D herbicides reduced hatching ability of chicken eggs and caused sterility in pheasant chicks (Duffard and Traini, 1981; Lutz and Lutz-Ostertag, 1972). Exposure of tadpoles to pesticides caused longer metamorphosis behavioral and growth abnormalities and decreased ability to catch prey and avoid predators (Sciencedaily, 2006). Herbicides, atrazine can turn male frogs into hermaphrodite and reduce reproduction ability (Sciencedaily, 2006).

4.4 Impacts of pesticides on human health

Pesticides can enter the body through various routes such as inhalation of aerosols, dust and vapours contaminated with pesticides; through consuming contaminated food/water; and through direct contact with skin (Bhandari et al., 2020). The toxicity of chemicals and the duration of exposure determines the effects of pesticides on human health (Lorenz, 2009). According to WHO, each year about 3,000,000 cases of pesticide poisoning and 220,000 deaths are reported in developing countries (Lah, 2011). Children are more susceptible to pesticides since they have weak immune system than adults. Farm workers and their families experience the greatest exposure to agricultural pesticides through contact. A group researchers stated that poor households begin to keep hazardous pesticides during the time of green revolution which increases suicides rates resulting in an estimated fourteen million premature deaths (Karunarathne et al., 2020). In a study state that pesticides are mostly misused intentionally as an easy means of committing suicide (Gyenwali et al., 2017).

Pesticides can cause several effects such as mild skin irritation, birth defects, tumors, genetic change, nervous disorder, endocrine disruption, and finally coma or death at last (Lorenz, 2009). Pesticide exposure can affect the nervous system such as loss of coordination and memory, reduced visual ability, reduced motor signaling; damages the immune system; and can cause hypersensitivity, asthma and allergies (Lah, 2011; Culliney et al., 1992). Also, the presence of pesticides in the human body affects reproduction capabilities by altering the levels of male and female reproductive hormones (Mahmood et al., 2016). A researcher found that increase in case of incidences of congenital anomalies, delayed puberty, mental retardation, abortion and cancer in the areas spread with endosulfan in India (Adithya, 2009). A group researcher said that the exposure during pesticide storing, mixing, applying and disposing of chemicals gets summed up to form total exposure (Antonella et al., 2001). Focusing on fact that short term and long term consequences of pesticide are real, Atreya and Sitaula, said that long term effects of the pesticide have not yet been studied in Nepal however, it is clear that pesticides are being applied at a higher rate than those recommended which is inviting serious risk (Atreya and Sitaula, 2011). Most of the vegetables sold are grown by independent farmers who set their own protocol for the dose of pesticide being indifferent to the standard recommendation that makes consumers at high risk of buying a significantly high amount of pesticide residues. Compared to cereals heavier application of pesticides is found in vegetables up to 90% of total pesticides (Atreya and Sitaula, 2011). A group researchers found that safety measures used by farmers were not satisfactory; further the negligence on safety measures during storage, handling and application of pesticides, even by the farmers who were aware of negative effects on pesticides (Bhandari et al., 2020).

4.5 Alternatives of pesticide use

Only banning the pesticide cannot be the ultimate solution for pesticide problems but the best alternative sustainable solution should also be introduced to the farmers. Palikhe reported that Integrated Pest Management (IPM) has been put forth as the best tool for 21st century Plant protection (Palikhe, 2002). IPM is the guiding principle for the pest control and it is the best option for the future as it guarantees yield, reduces costs, environment friendly and contributes to the sustainability of agriculture. Palikhe also reported that there are several plant species, which grow naturally in abundance and may provide quite effective safe and economical bio-pesticides (Palikhe, 2002). Losses during pre-and post-harvest activities in the field and storage which ranges from 15-35% are caused by pests and if the loss can be minimized, it can play a significant role in food security (Adhikari, 2018; Palikhe, 2002). The alternatives for the present chemical-based agriculture can be bio-pesticides, optimizing the environment for natural enemies, management practices such as destruction of habitat. Natural farming or Do Nothing farming proposed by Masanobu Fukuoka also gives hope for the better future, who says methods of insect control, which ignore the relationship among the insects themselves, are truly useless (Fukuoka, 2009).

Therefore, the new concept, ecologically based integrated pest management (EBIPM) practices came in 1996 which emphasizes tri-trophic interaction among host plant, insect and natural enemies and their holistic management practices such as cultural control, biological control and host plant resistance (Samal and Bhattacharjee, 2020; Overton, 1996). EBIPM practices also consider the integration of different tactics of pest control such as biological (e.g. parasites, predators and fungi), chemical (e.g. selective pesticides and pheromones), cultural (e.g. crop rotation, planting date and soil fertility) and physical aspects (e.g. tillage and aeration) for the deployment of better management practices.

We should not also overlook the indigenous technical knowledge (ITK) which has been generated by the farmers' practices from decades and being passed from generation to generation which also encloses the IPM techniques within. Some IPM techniques used by Nepali farmers as listed in Krishi Diary-2020 are use of neem (*Azadirachta indica*), timur (*Zanthoxylum piperitum*), bojho (*Acorus calamus*), titepati (*Artimisia vulgaris*), jwano (*Trachyspermum ammi*), rapeseed (*Brassica campestris*) oil to manage the storage pests. Wood dust, cow's urine, soap-water solution, tobacco extract to control insects in vegetables, use of traps, baits, pheromones, jholmol, whey and conservation of the natural predators to manage insect pests (MOALD, 2020). Also, the emphasis should be given on the use of resistant varieties, cultural methods, physical and mechanical methods, chemical attractants, and chemical methods should be used only as last resort.

5. Conclusion

Pesticides are regarded as a quick and easy solution for controlling insect pests, diseases and weeds. However, pesticide use comes at a significant cost. Pesticides have contaminated almost every part of environment since its residues can be found everywhere. Pesticide contamination causes significant impacts to the ecosystem and non-target organisms. To conclude, we need to self-investigate our actions so that we can protect this earth for the present generation and future generations. We need to be far-sighted while performing our deeds and their corresponding consequences and start to take adapting and mitigating actions as soon as

possible. We should avoid the use of chemicals and pesticides to the extent it is possible because the so-called safe dose may also start showing their ill effects in the long run. It is not compulsory to rely on the chemicals and pesticides as there are many safe, sustainable and reliable alternatives of chemical pesticides. We need to see from an ethical and ecological point of view too, as commercializing and gaining the money should not be our only aim. Farmers should be made aware that the pesticides are poisons, not medicine; they should be well acquainted with the recommended dose and safe ways of using them. Local methods of pest controls including ITK and IPM should be prioritized and farmers should be encouraged and motivated to use and enhance those methods, as well as government and extension workers should prioritize the more safe, natural and sustainable measures of pest management. We should realize as soon as possible that we share this earth with all the living creatures and they too have equal right as we do have, going in the same track as we are going now is bound to cause a serious accident with humankind in near future.

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