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Review on Need of Utilization of Biopesticides in Agriculture for Safe Environment

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ABSTRACT

Ancient knowledge of natural resources was neglected and harmful and hazardous chemicals produced on large scale in developed countries were utilized as agriculture inputs in the form of insecticides, pesticides, fungicides, fertilizers etc. These chemicals were applied unwisely and improperly which has became the death cause for lakhs of animal and human lives and of fatal diseases world over. WHO, FAO and UNEPA have taken care and banned some of them in developed countries, but for one or another reason they are still in use in the developing countries. To fulfill the food demand of ever increasing population, agriculture production must be kept increasing from the decreasing land under crops. In this context there may be an alternative of biochemicals (plant, animal, bacteria, virus and fungal source) and implementation of IPM programme with justified use of some chemicals for the safety and longevity of the human being on the earth.

Key Words:- MRL- minimum risk level, IPM-Integrated Pest Management, PGIMER-Postgraduate Institute of Medical Education & Research, Chandigarh, COD- chemical oxygen demand, BOD- biochemical oxygen demand,

Introduction

Ever increasing population and increasing demands for insecticides, pesticides, fungicides, medicines, cosmetics, paints and varnishes, enamels, etc. in Agriculture, food, clothing, shelter and allied industries had been a driving force to use chemicals which have been proved persistent and harmful to biotic and abiotic factors on the earth. Many reports world over have shown that residues of harmful chemicals have reached at every corner of food materials from food grains to the breast milk (WHO,1990). Green revolution in agriculture has witnessed ample food production as well as huge and rampant application of harmful chemicals in agriculture and lateron other related industries, where the safe boundary levels have been crossed. Increasing population, urbanization and industrialization will be continued probably the rate will increase in future and these may be the uncontrollable factors in future. Most of the hazardous chemicals banned in many developed countries are still in use in developing countries world over (UNEP, 2000; Venkateswara, et. al., 2005) in many countries which has serious deleterious impacts on non-targeted biotic and abiotic factors of environment (Pimental, 1995).

Illiteracy, poverty, small and marginal land holdings and lack of money and awareness in farmers of developing countries is forcing to use harmful chemicals and that to without safety precautions, which is leading to death cause and of fatal diseases for them directly and to others indirectly polluting environment (Venkateswara, et. al., 2005). The climate change factors have added in the confusion among scientists about the unseasonal rains, changing feeding nature of insects and pests and developed resistance against chemicals used in agriculture. Therefore it is necessary to focus on biochemicals (plant, animal, bacteria, virus and fungal source) and implementation of IPM programme with justified use of some chemicals for the safety and longevity of the human being on the earth.

Review of Literature

Number factors are responsible for the different types of pollution and its ill effects on biotic and abiotic world on the earth, which is threatening for the safety existence of the human being on the earth for long period. Many scientists from different countries have observed the residues of hazardous chemicals used in agriculture especially after green revolution, have been reviewed under different subheadings as below.

1. Use of pesticides and herbicides

Total human life is exposed to pesticides and major burden of serious health effects shouldered by developing countries and by high risk groups in the world (WHO, 1990). About 1 million per year human deaths and chronic diseases due to pesticide poisoning are observed world-wide (Environews Forum, 1999). Workers in involved from production industry to the use by farm workers are the high risk groups exposed to pesticides. Organochlorides could pollute the tissues of virtually every life form on the earth, the air, the lakes and the oceans, the fishes that live in them and the birds that feed on the fishes (Hurley et al., 1998).

2. Polluted food commodities

Most of the pesticides (acephate, chlopyriphos, chlopyriphos-methyl, methamidophos, iprodione, procymidone and chlorothalonil) in fruits and vegetables (apples, tomatoes, lettuce, strawberries and grapes) were analysed (9700 samples) under 'Monitoring of Pesticide Residues in Products of Plant Origin in the European Union' started since 1996, and were found to contain pesticide residues higher than the respective MRL for that specific pesticide. In the first report of poisoning due to pesticides from Kerala (India) in 1958, over 100 people were died after consuming parathion contaminated wheat flour (Karunakaran, 1958). In a multi-centric study (Surveillance of Food Contaminants in India, 1993) to assess the pesticide residues in selected food commodities from different states of the country, the proportion of the samples with residues above the tolerance limit was observed highest in Maharastra (74%), followed by Gujarat (70%), Andhra Pradesh (57%), Himachal Pradesh (56%), and Punjab (51%). In the remaining states, this proportion was less than 10% (Kannan et al., 1992).

3. Impact on environment

Pesticides can contaminate soil, water, turf, and other vegetation. In addition to killing insects or weeds, pesticides can be toxic to a host of other organisms including birds, fish, beneficial insects, and non-target plants. Insecticides are generally the most acutely toxic class of pesticides, but herbicides can pose more risks to non-target organisms.

a) Surface water contamination

Contamination of surface water by pesticides is widespread through runoff from treated plants and soil. In the set of studies done by the U.S. Geological Survey (USGS) on major river basins across the country in the early to mid- 90s shows that more than 90 percent of water and fish samples from all streams contained one, or more often, several pesticides commonly exceeded guidelines for protection of aquatic life (Kole et al; 2001, Bortleson and Davis, 1987–1995, U.S. Geological Survey, 1999).

A joint study by PGIMER and Punjab Pollution Control Board in 2008, revealed that in villages along the Nullah, fluoride, mercury, beta-endosulphan and heptachlor pesticide were more than permissible limit (MPL) in ground and tap waters. Plus the water had high concentration of COD and BOD (chemical and biochemical oxygen demand), ammonia, phosphate, chloride, chromium, arsenic and chlorpyrifos pesticide. The ground water also contains nickel and selenium, while the tap water has high concentration of lead, nickel and cadmium (Indian Express, 2008). Water pollution severely limits the amount of water available to Indian consumer, industry and agriculture. It has been suggested that water pollution is the leading worldwide cause of deaths and diseases and that it accounts for the deaths of more than 14,000 people daily (West, 2006). An estimated 580 people in India die of water pollution related illness every day (Chnri, 2010).

Some examples of river water pollution by pesticides are explained in brief as..

Ganges river pollution is a major health risk (Hyde, 2010) because of the establishment of a large number of industrial cities on the bank like Kanpur, Allahabad, Varanasi and Patna, countless tanneries, chemical plants, textile mills, distilleries, slaughterhouses, and hospitals prosper and grow along this and contribute to the pollution of the Ganga by dumping untreated waste into it. Industrial effluents are about 12% of the total volume of effluent reaching the Ganga. Although a relatively low proportion, they are a cause for major concern because they are often toxic and non-biodegradable (http://www.hindustantimes.com).

By an estimate in 2012, Delhi's sacred Yamuna river contained 7,500 coliform bacteria per 100cc of water. Though the Yamuna starts getting polluted by pesticides and fertilisers as it enters Haryana, most of the pollution occurs in Delhi (The Hindu, 2002). The agriculture is also one of the main sources of contamination in the Yamuna River, which directly or indirectly affects river water quality through, ground and surface water runoff of agricultural land through monsoon and non-monsoon precipitation and seepage of irrigation water, which is composed of artificial fertilizer residues, insecticides, herbicides, pesticides and farmyard waste. Agriculture is very common in the catchment areas as well as all along the bank of the Yamuna River. Usually in the non-monsoon time majority of the river streams shrinks and their catchment areas are used for farming and thus directly contributing pesticides residue in the river (Misra, 2010).

Water quality of Narmada rivers is polluting fast due to chemicals from different sources and huge quantity of waste from cities and villages situated along the river and effluents discharged from industries have pushed the quality of water down to "B" category, according to Bureau of Indian Standard 2296 norms. Godavari river water is also being polluted by the huge chemicals and sewage water (84-92%) and industrial waste (8-16%) (Dhirendra, 2009) from Maharashtra, Telangana, Andhra Pradesh and Orissa. Mula and Mutha rivers in Pune have become gutters because of pollution added in from different sources. Due to high levels of pollution, including 125 MLD of untreated sewerage water being discharged into the river by the Pune Municipal Corporation, the Maharashtra Pollution Control Board has classified the water quality to be of Class-IV (Maharashtra Pollution Control Board. 2014).

b) Ground water contamination

Pollution of groundwater due to pesticides is a worldwide problem. In India, 58% of drinking water samples drawn from various hand pumps and wells around Bhopal were found contaminated with Organo Chlorine pesticides above the EPA standards (Kole and Bagchi, 1995). Once ground water is polluted with toxic chemicals, it may take many years for the contamination to dissipate or be cleaned up which is very costly and complex, if not impossible (USEPA, 2001).

c) Soil contamination

Because of application of number of chemicals as pesticides, insecticides, fungicides, herbicides and chemical fertilizers, residues are found in soil everywhere in the world. Some of them can be moved from soil by runoff and leaching, thereby constituting a problem for the supply of drinking water to the population (Andreu and Pico, 2004).

d) Effect on soil fertility (beneficial soil microorganisms)

Plants depend on a variety of soil microorganisms to transform atmospheric nitrogen into nitrates, which plants can use. Pesticides and herbicides disrupt this process depleting the population of beneficial soil microorganisms and fungi (Savonen, 1997).

4. Contamination of air, soil, and non-target vegetation

Pesticide and herbicide sprays can directly hit non-target vegetation, or can drift or volatilize 2 to 25% of the chemical being applied from the treated area and spread over a distance of a few yards to several hundred miles contaminating air, soil and non-target plants (Glotfelty and Schomburg, 1989). As much as 80–90% of an applied pesticide can be volatilized within a few days of application (Majewski, 1995). In addition to killing non-target plants outright, it cause sublethal effects on plants, increase the susceptibility of certain plants to disease, posing a special threat to endangered plant species (Brammall and Higgins, 1998).

Pesticides and herbicides are found as common contaminants in soil, air, water and can harm plants and animals ranging from beneficial soil microorganisms and insects, non-target plants, fish, birds, bees, spiders and other wildlife (USEPA, 1996;1998, Liong et al., 1988). Birds, fish and other marine animals have adverse effects on the reproductive and immunological functions in captive or wild aquatic mammals and plants (Helle et al., 1976). The Ganges river basin is densely populated and heavily polluted by fertilizers, pesticides, and industrial and domestic effluents and observed containing concentrations of heavy metals and hazardous chemical residues (Kannan et al., 1997).

Materials and Methods

Chemicals used as insecticides, pesticides, herbicide and fungicides are costly and hazardous to human, animals and environment. In this context biopesticides derived from such natural materials as animals, plants, bacteria, pheromones, and certain minerals will be an environment friendly alternative. As of April 2016, there are 299 registered biopesticide active ingredients and 1401 active biopesticide product registrations (USEPA, 2016).

Recently, the WHO's estimate indicated that, 25 million cases of acute occupational pesticide poisoning in developing countries and 20,000 deaths world-wide each year. Controlling such insect pests is necessary to increase agricultural production. About 70,000 pest species including 9,000 sporadic insect species cause damage in agricultural crops worldwide. Globally, 1000 insect pest species are known as major pests. In India, 200 insect species are remarked as serious pests and are economically important. Without the use of pesticides, insect pests caused 70% losses in agriculture (Krattiger, 1997). Traditionally, farmers and practitioners have developed a variety of bio-pesticides, farming and storage practices that contribute either directly or indirectly to insect pest management. In India, about 70 traditional practices are followed for the control of insects and other pests (Ignacimuthu, 2004). However, eco-friendly insect pest management in India is a difficult task in the current trend.

Biopesticides major classes:

1. Biochemical pesticides are naturally occurring substances that control pests by non-toxic mechanisms. Biochemical pesticides include substances that interfere with mating, such as insect sex pheromones, as well as various scented plant extracts that attract insect pests to traps. Because it is sometimes difficult to determine whether a substance meets the criteria for classification as a biochemical pesticide, EPA has established a special committee to make such decisions.
2. Microbial pesticides consist of a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest[s]. For example, there are fungi that control certain weeds and other fungi that kill specific insects.

The most widely used microbial pesticides are subspecies and strains of Bacillus thuringiensis, or Bt. Each strain of this bacterium produces a different mix of proteins and specifically kills one or a few related species of insect larvae. While some Bt ingredients control moth larvae found on plants, other Bt ingredients are specific for larvae of flies and mosquitoes. The target insect species are determined by whether the particular Bt produces a protein that can bind to a larval gut receptor, thereby causing the insect larvae to starve.

3. Plant-Incorporated-Protectants (PIPs) are pesticidal substances that plants produce from genetic material that has been added to the plant. For example, scientists can take the gene for the Bt pesticidal protein and introduce the gene into the plant's own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest. The protein and its genetic material, but not the plant itself, are regulated by EPA.

Factors affecting growth of biopesticides

However, some of the factors which have restricted the growth of biopesticides are:

- Low reliability because of low stability in effect
- Target specificity which distracts farmers
- Slow in action compared to synthetics
- Shorter shelf life
- Erratic availability of biopesticides in the market
- Already established and strong market of chemical pesticides
- Regulatory system favorable to chemical pesticides, and
- The gradual disappearance of multiple or mixed cropping, which is known to keep away the magic bullet-chemical pesticide.

Advantages of using biopesticides

1. Biopesticides are usually inherently less toxic than conventional pesticides.
2. Biopesticides generally affect only the target pest and closely related organisms, in contrast to broad spectrum, conventional pesticides that may affect organisms as different as birds, insects and mammals.
3. Biopesticides often are effective in very small quantities and often decompose quickly, resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides.
4. When used as a component of Integrated Pest Management (IPM) programs, biopesticides can greatly reduce the use of conventional pesticides, while crop yields remain high.
5. To use biopesticides effectively (and safely), however, users need to know a great deal about managing pests and must carefully follow all label directions.

Biopesticide production and Consumption

Global pesticide use has increased 50-fold since 1950, with the drastic growth in human population although the average consumption level of is approximately 1 kg/ha. With the global organic farming area comprising about 24million hectares, global biopesticide consumption is thus estimated at about 24 million kg. The Biopesticide market is growing very rapidly and is to boost at 9.9% from 2015 to 2023 because of global Agriculture Industry acting as market growth driver (Albany, 2016). In terms of use, orchards claim the largest share (55%) of the total biopesticides used. North America consumes the largest share (40%) of the global biopesticide production followed by Europe and Oceanic countries accounting for 20% each(Albany, 2016).

Out of the total pesticides produced, the utilization of synthetic pesticides in India is about 50% for cotton crop alone followed by 17% on rice (Gahukar, 1997). Presently, the average per hectare consumption of pesticides in India is about 280 g/ha and consumption of pesticides is increasing at the rate of 2 to 5% per year. It is noteworthy that the consumption of chemical pesticides in India is very low (381 grams per hectare) in comparison with the global consumption (500 grams per hectare) at present. Arora et al. (2009) pointed out that 40,000 metric tons of pesticides are used in India every year.

Bio-pesticides are potential alternatives to synthetic chemical pesticides. It was known that, biopesticides are living natural enemy organisms and/or their products including plant and microbial products and/or their byproducts and they could reduce pest populations. In the present decade, biopesticides are widely acceptable and demanded for sustainable agriculture and for production of safer foods. It was significantly considered that, biopesticides are ecofriendly, target-specific, easily biodegradable and safer alternatives. Economically, chemical pesticides can be very expensive in comparison to bio-pesticides. Currently, in India 230 pesticides are registered under section 9(3) of the Insecticide Act, 1968 as on 17/06/2011 for use and technical grade pesticides are manufactured indigenously. However, bio-pesticides may represent about 4.2% of the overall pesticides market in India (Das, 2014). Globally, biopesticides production is 4.5% and in USA it is 6%, whereas in India, it accounts only 3% of the total chemical pesticides production. Presently, only 12 types of biopesticides including neembased and microbial based formulations are registered under the Insecticide Act, 1968 in India.

In Indian perspective, there is a needful demand to increase productivity of biopesticides for pest management and sustainable agriculture. Currently, phytochemical and natural product studies have led to the discovery of enormous number of compounds with a variety of chemical structures and bioactivities. Botanical pesticides are potential alternative sources and are not harmful and eco-safe. It is also known as 'phytochemical insecticides' and 'green-chemical insecticides'. Recently, Isman (2014) reported that, publications numbers are increasing in botanical insecticide research especially in India, China and Brazil; but the application value is less. An alternative way of research is required to fulfill the demand of production of botanical pesticides for promoting of organic farming and integrated pest management (IPM) in developing countries. India possesses the largest diversity of plant species having 47,000 plant species and accounts for 7-8% of the recorded species in the world. New chemicals are being isolated and characterized every day from plant and other biological sources. Till date, more than 6,000 species of plants have been screened against various types of pests. There are about 1005 species of plants exhibiting insecticidal properties, 384 with antifeedant properties, 297 with repellent properties, 27 with attractant properties and 31 with growth inhibiting properties (Singh, 1999). However, commercialization of phyto-chemicals and phyto-essential oils for insect pest management is very less. Challenges to the commercial application of plant based insecticides include availability of sufficient quantities of plant material, standardization and refinement of insecticide products, protection of technology (patents) and regulatory approval.

In United States, pesticide registration policy and commercialization is greatly relaxed for commonly used plant oils as insecticides for processed foods. Some U.S. companies have introduced oil-based insecticides in recent years. Similarly, registration restriction regulations are required in India. Recently, Packiam et al., (2012) formulated and patented a phytopesticide 'Ponneem' for field crop insect pest management, and few pest control devices were developed and patented from Tamil Nadu Agricultural University, Coimbatore for stored product insect pest management. Similarly, new more eco-friendly pesticides, pest control devices and strategies are required for promoting biopesticides for IPM and production of healthy and safe foods in India.

The striking feature of biopesticides is environment friendliness and easy biodegradability, thereby resulting in lower pesticide residues and largely avoiding pollution problems associated with chemical pesticides. Further, use of biopesticides as a component of IPM programs can greatly decrease the use of conventional (chemical) pesticides, while achieving almost the same level of crop yield. However, effective use of biopesticides demands understanding of a great deal about managing pests especially by the end users.In terms of production and commercialization also biopesticides have an edge over chemical pesticides like low research expenditure, faster rate of product development as well as flexible registration process (Sinha and Biswas, 2008).

The aim of this article is to emphasize on the utilization of alternatives for chemical insecticides and pesticides to reduce environmental pollution simultaneously to avoid biotic and abiotic health hazards and enhance the employment opportunities in rural areas.

Conclusions

Global warming and climate change have made us aware of environmental pollution and health risks to life. Increasing population, industrialization and urbanization especially in developing countries is diverting the focus of governments from the severity of pollution hazards. For developing countries it is imperative to use pesticides to control famine and communicable diseases like malaria means to be expedient to accept a reasonable degree of risk. Pesticides are often considered a quick, easy, and less expensive solution for controlling weeds and insect pests in urban landscapes which have contaminated almost every part of our environment and non-target organisms ranging from beneficial soil microorganisms, to insects, plants, fish, and birds. Pesticide residues are found in soil and air, and in surface and ground water across the countries and contribute to the problem.

The best way to reduce pesticide contamination (and the harm it causes) in our environment is to use safer, non-chemical pest control (including weed control) methods (i.e. biopesticides and other alternatives) in agriculture to develop the eco-friendly biosphere in soil, air and water. Biopesticides are highly specific affecting only the targeted pest or closely related pests and do not harm humans or beneficial organisms while chemical pesticides are broad spectrum and known to affect non-target organisms including predators and parasites as well as humans.

Our efforts should include judgmental use of insecticides, pesticides, fungicides, chemicals and investigations of biopesticides as safe alternatives as for as possible. By achieving economic benefits, social and environmental benefits should not be neglected at any of the level. The ultimate benefit that should be focused on global level is the safe existence of human on the earth for longer period of time.

This is high time to understand by every person, group of persons, institutions and governments in the world to plan the economic development in one hand and socio-environmental benefits in another hand for sustainable livelihood on the earth. There is thus every reason to develop health education packages based on knowledge, aptitude and practices and to disseminate them within the community in order to avail alternate natural resources and minimize human exposure to the controlled and justified use of pesticides for safe human life on the earth.

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