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Impact of Pesticide Usage on Water Resources: Indian Scenario

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Abstract: ***The term Pesticide is generally used for agrochemicals which are important for crop protection. They are amongst the primary means required to sustain and improve the agricultural production. Crop production and their protection techniques play a very crucial role to meet the needs of a growing population. A significant part of entire food production is washed out owing to insect pests, plant pathogens, weeds, rodents, birds, nematodes in agricultural fields and when in storage. In last few decades pesticides industry has developed to a large extent and it contributes significantly towards India's agriculture and public health. However, use of pesticides causes both environmental and human health hazards. The toxic effect of a pesticide depends on nature of pesticide, means and period of exposure and its dose. Pesticides move through air, soil, and water, finding their way into living tissues, where they undergo biological modifications. So many cases of pesticide pollution in Indian river stretches, estuaries and drinking water have been reported. Water pollution in India with special reference to pesticides has been discussed in this review.***
KeyWords: Pesticides; crop protection; Water pollution; Toxicity.

I. INTRODUCTION

To fulfill the increased requirement of food due to fast growing population and for safe storage of crops, use of pesticides is need of time. Contrary to this, pesticides usages have caused many severe troubles also [1]. If on one side, India and other countries achieved self-reliance in crop production by use of pesticides, on the other hand, their unsystematic use has noticeably contaminated the environment. A large amount of waste material is produced due to their overuse and misuse which contributes to the undesirable impacts on environment and health. Thus, improper use of pesticides influences the entire flora and fauna by inflowing of the remains in food cycle and contaminating the lithosphere, atmosphere and hydrosphere [2]-[4].The amplified application of chlorinated non-degradable pesticides increases residue in various biotic components for extended time of retention which are most probably the reason for a variety of toxic symptoms [5].

Thus, present global developmental method using pesticides is not green and practicable over the long term, and all ecosystems are facing danger at different timelevels, having impact on food, water, energy, biodiversity and mineral resources. By extrapolating the current available data, it is estimated that by 2025, more than 50% countries in the world will face water related problems. [6].

II. PESTICIDES

A Introduction

The U.S.E.P.A. [41] gives definition of pesticide as a substance or combination of substances which is proposed for avoiding, devastating, repelling, or mitigating any pest. The term pesticide may also be explained as any physical, chemical, or biological agent that is capable of killing an unwanted plant or animal pest. The term "pest" describes damaging, destructive, or troublesome animals, plants, or microorganisms.

B Historical Development

Over the centuries, human beings have explored many creative and ingenious methods to control the insects, weeds, fungi and microorganisms that continuously endangered the protection of food and causing a threat to health.

Chinese were using Sulphur as a fumigant before 1000 B.C. and Europeans were using it against powdery mildew on fruit as a fungicide in the 1800s.

In the mid-1800s, the pulverized root of *Derris eliptica,* containing rotenone, was used as an insecticide, as was pyrethrum extracted from the flowers of the chrysanthemum (*Chrysanthemum cinearіaefolum*).

At the end of 1800s, arsenic trioxide was applied to kill weeds, mainly dandelions.

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By the 1900s, the widespread use of arsenical pesticides caused considerable public concern because some processed edibles e.g. fruits and vegetables were reported to have their toxic residues.

Even though a few of these ancient pesticides created only minimal damage to the humans affected, other pesticides were remarkably toxic. Before the 1930s, very few pesticides were existing for application. By the 1930s, the age of advanced synthetic chemistry started and a variety of chemicals such as alkyl thiocyanate insecticides, dithiocarbamate fungicides, ethylene dibromide and ethylene oxide were developed [8].

By the start of Second World War, many pesticides, including dichlorodiphenyltrichloroethane, dinitrocresol, 2-methyl-4-chlorophenoxyacetic acid, and 2.4-dichlorophenoxyacetic acid were under exploration [9].

In the post war age, the agrochemical field was developed rapidly and excess of insecticides, fungicides, herbicides, and other chemical agents were developed.

III. THE ROLE FOR PESTICIDES

India accounts for only about 2.4% of the world's geographical area and 4 % of its water resources, but has to support approximately 18% of the world's human population. India is world's second largest nation with a population of 1.3 Bn.

Due to rapidly growing population, need to increase food production become essential all over the world [10, 11]. The widespread elevated temperature and humidity of tropical countries, which is inductive to fast growth of pests causes severe crop loss. Therefore to meet up the increased food demand, the control of pests, in these countries becomes very important. In India, the task has been made possible by the Green Revolution of 1960 and thus the country became self - dependent in the production of ample food for its people as well as the major producer of a few essential crops [12].

However, it is not only economic losses that bring about effective pest control an urgent need. All over the world, millions of people are killed or troubled yearly from insect caused ailments. For that reason, it is an urgent requirement to manage various harmful organisms for the better future of agriculture, industry and human health. Thus Pesticides use becomes vital in food production, clothing, preventing many diseases and protecting the population [13] which according to United Nations became six billion on 12th October 1999, the "Day of Six Billions". It is expected that the world's population will reach 8.04 billion by the year 2025 [13]. Therefore, to fulfill food needs of growing population, pesticides role is vital.

IV. PESTICIDE USAGE IN INDIA

In India, pesticides are mainly used in the field of agriculture and society health to fight a variety of pests and diseases that have an effect on human beings. In 1948–49, the era of synthesized pesticides had begun by applying DDT to combat malaria and Benzene hexachloride to combat locust [12, 6, 14].

India is the fourth largest producer of agrochemicals in the world after USA, Japan and China. The 60% of the total pesticides used in India is insecticide, herbicides (16%) and fungicides (18%) are lesser used [15]. According to an analysis, Indian Pesticide Industry, July 13, 2011, Pesticide consumption in India is one of the lowest in the world with per hectare consumption of less than one kg compared to US (4.5 kg/ha) and Japan (11 kg/ha). [16].

The consumption of pesticide is showing a slight declining trend, probably due to shift of farmers toward biopesticides, natural plant sources and other alternative methods [17]- [18]. Currently bio- pesticides constitute only 3% of Indian crop protection market [15]. The tendency of pesticides application in India is different from other countries of the world [19].

The warm moist and tropical weather provides the promising reproduction atmosphere for insects which is probably the reason for more consumption of insecticides in India [20].

V. TOXICITY OF PESTICIDES

Presently many advanced pesticides are in use in various sectors including agriculture and health sector. Now, several second- and third generation derivatives of the previous chemical pesticides have been evolved. In spite of the advancement of pesticides, new ones are not very efficient in target-species selectivity as per expectation and therefore non-target species are often influenced hence completely safe pesticides are not available. However, some pesticides exhibit less risk level to human health when label's information is properly followed during their application [21]. In fact, the methodologies of pesticide application have been designed in such a way that only target pests are attacked and killed by them and the non-target organisms remain uninfluenced. The dosage required to kill any pest causes many problems to humans such as disturbance in sex hormone functioning and reproductive performances [22]-[25]. Many times pesticides mimic hormone like properties thus acting as xenohormones or they interfere with endocrine functions. Therefore they are also categorized as endocrine disruptors [26].

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In the early 1960s, dangerous effects of pesticides on human health and its prolonged impacts on the food chain were observed first time. In India, the first incident of such type of harmful effects was reported in the states of Kerala in 1958, where more than 100 people died due to parathion mixed wheat flour ingestion [27]. The Federal Economic Poisons Act (USA) and Miller Bill were the two important decisions regarding analysis and study of pesticide toxicity. The FEPA registers pesticides as separate chemical additives while Miller Bill recognized the tolerance limits of pesticide residues in food crops [28]. The legislations on the pesticides usage and related risks were also significantly changed after the first investigation of environmental hazardous effects of pesticides in 1962 [29].

VI. WATER POLLUTION BY PESTICIDES

Water is very important for living organism. It is one of the essential companions of life on earth. It has always contributed as most essential constituent of life not only during creation and evolution period of life but also its survival on earth. It is important because it acts as a universal solvent and has key role in metabolism occurring within the body. Therefore, existence of life is not possible without hygienic and clean water [30]. Water pollution may be defined as any unwanted modifications in the chemical and physical characteristics of water which are unfavorable to all those living things consuming water for their existence.

Environment Protection Agency (EPA) published a report in 1990 that discharge and mixing of chemicals from the agriculture practices is responsible for more than half of the water pollution of streams and rivers [25].

Groundwater resources are contaminated by pesticide in many ways:

Residues of pesticides, which have been applied to agricultural fields, may percolate into subsurface waters.

These residues may dissolve in water flowing on surface and contaminate surface water.

If applied as spray, pesticides may be carried to surface waters via spray drifts.

These residues may be converted into products that also pollute water [19].

The potential of pesticide to contaminate water depends on several factors —

The solubility of the pesticide in water.

Abiotic component of environment such as soil, weather etc.

The distance between water bodies and the place of pesticide application [31].

The effect of pesticides on the water quality depends on the following aspects-Active ingredient (a.i.) in the pesticide formulation.

Impurities that may contaminate the a.i.

Additives that are mixed with the a.i.

Degrades which are produced during degradation of the a.i. [32].

The main route of pesticide contamination is its potential to adversely affect the water systems, which is vital not only for human life, but also for aquatic life. Pesticides can enter water through basic processes associated with the Water Cycle of earth like surface runoff or leaching [25]. Pollutants may enter water bodies by air or by their own movement. Pollutants can move either through point sources or non- point sources [31].

VII. PESTICIDE POLLUTION CASE STUDY IN INDIA

The farmers and agricultural people are the direct users of pesticides and are more likely to get affected by the acute toxicity of pesticides. The harm caused to them may be acute or chronic in nature. The chronic toxicity affects the whole population.

The major tool of pollution profile studies is the water quality index (WQI). The first formal WQI in the literature was proposed by Horton in 1965 [33]. The first reported Indian WQI was used for zoning and classification of river Ganga with respect to specific issue of drinking water supply [34]. It was recommended that the public drinking water supplies should have a WQI higher than 90 [35].

A. Pesticide Pollution in Rivers

The impact of river water pollution on aquatic animals and plants is hazardous all over the world. The bioaccumulation of pesticide in fishes of north India was studied in 2008 by Singh and Singh [36]. The residue level of both HCH and DDT were reported to be high in surrounding air and rain water in Delhi region during 1980 to 1982 [37,38]. Pillai in 1986 [39] reported that about 70% of pesticides employed in India are organochlorine insecticides such as DDT and HCH. Nair et al. 1992 [40]. studied the levels of DDT and HCH residues in abiotic and biotic components of the environment of Delhi between 1988 to1989 and disclosed low to moderate levels of these insecticides in soil, earthworms, birds, buffalo milk, water, freshwater clams, fish, human fat, human blood and breast milk sample. The Yamuna River which is responsible for water supply to Delhi is among the most polluted rivers in

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India. The waste including huge amounts of domestic and industrial effluents comes from the city located all along its bank which contributes to the pollutants flowing into the river. Mutagenicity assessment of Yamuna River water demonstrated that a mixture of genotoxins with both bacterial mutagenic and genotoxic effects polluted the Yamuna River water at Okhla, Delhi [41].

Water samples from Ganga river from 3 different locations viz. Kachla, Fatehgarh and Kannauj (U.P.) showed the presence of some organochlorine pesticides like DDT, β-BHC, aldrin, dieldrin etc. DDT, α-BHC, DDD, aldrin and dieldrin and the organophosphorus pesticides like dimethoate and methyl parathion [42].The test samples exhibited a remarkable degree of mutagenicity with TA98, TA100 and TA97a strains with the role of contaminating pesticides in the river water. Vijayraghvan et al.1994 also suggested genotoxic effect of some organochlorine and organophosphorus pesticides [43].

It is true that pesticides fulfilled increasing demand of food but excess use of pesticides have negative impact on the human health and their surroundings. From Agricultural fields they come into soil, air, and water and enter human body effecting body organs badly. Undoubtedly concentration of pesticides is increasing in the atmosphere day by day and therefore it is urgently required to develop a suitable method for their removal.

B. Pesticide Pollution in bottled water and soft drinks

Amid July and December 2002, the Pollution Monitoring Laboratory, Centre for Science and Environment (CSE), New Delhi investigated the packaged water of seventeen brands, usually traded in NCR of Delhi. It was reported that organochlorine and organophosphorus pesticide residues were present in all samples in amounts more than the permissible limits specified by the European Economic Community (EEC). Among the OCPs, gamma-hexachlorocyclohexane (lindane) and DDT were commonly present, while among OPPs, Malathion and Chlorpyrifos were the most common.

In another study reported by CSE in the month of May, 2003, Soft drink samples were tested applying a methodology based on United States Environment Protection Agency (USEPA) for OCPs and OPPs detection. Average concentration of total pesticides (organochlorines and organophosphorus) pesticides detected was found to be 34 times higher than the EEC limit.

It is true that pesticides fulfilled increasing demand of food but excess use of pesticides have negative impact on the human health and their surroundings. From Agricultural fields they come into soil, air, and water and enter human body effecting body organs badly. Undoubtedly concentration of pesticides is increasing in the atmosphere day by day and therefore it is urgently required to develop a suitable method for their removal.

C. *Pesticide Pollution in Milk of Woman, Buffalo, and Goat*

Milk is almost an ideal natural food which is extensively utilized by all human beings. It is a chief food material for infants, the ill people, and the aged-persons [45]. Human milk is rich in fat and it is the main and efficient resource of infant nutrition. Pesticides get accumulated in human milk in frightening amounts owing to their lipophilic nature. The comparative study of per capita use of agrochemicals in India and other developing countries show lesser consumption of agrochemicals in India. Contrary to this their accumulation in body tissues is comparatively more [46]. Organochlorine pesticides (OCPs) are the main contaminants of human milk amongst the reported environmental toxic compounds [47, 48]. The accumulation of xenobiotics in mother's milk is considered as a very severe trouble all over the world [49]. At first Laug et al. had reported OCP residues in human mother’s milk in 1950 [50]. John et al. in 2001 found that the amount of pesticide residues was more in milk samples collected in winter seasons than summer and rainy seasons [45]. Its main reasons are:

Pesticides are mainly used during the farming of seasonal vegetables and other standing crops.

During summer and winter season the influence of heat, wind, and rain is very high so the pesticides are dissipated quickly from the outside field environment where it is sprayed.

In winters the food of cattle contains more oil seeds, which accumulates OCPs and pesticide residue enters to the animal’s body through these oil seeds.

Jani et al. 1988 studied and reported the concentrations of alpha, gamma, and beta isomers of HCH, p,p'-DDE, p,p'-DDT, o,p'-DDT, p,p'-DDD, and PCBs in human milk samples from a selected group of mothers in Ahmedabad, India during 1981-1982 [51]. This investigation was performed under UNEP/WHO biological monitoring program on pesticide residues. This report had shown higher levels as compared with other countries e.g. Austria, Belgium, Canada, Sweden, and Yugoslavia [48, 52]. Saxena et al. 1982 analyzed milk samples of human, buffalo, and goat for organochlorine pesticides and found the order of contamination was human>buffalo>goat [53]. The reason accounting for the highest contamination in women is that women regularly consume buffalo milk and some goat milk as the major liquid foods. The pesticides come into buffalo and goat milk from various sources like straw,

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grass, etc. and easily enter the human body. Kalra et al. in 1994 compared the residue levels of DDT and HCH in the cotton-producing and other regions of the Punjab, India [49]. Siddiqui et al. 1981 reported considerable amounts of BHC and DDT in breast milk, in the vigorous flow in blood samples, and umbilical cord blood of mothers [54]. It demonstrates the pesticide trouble of lactating lady and also its shift from mother to infants.

VIII. CONCLUSION

It is true that pesticides fulfilled increasing demand of food but excess use of pesticides have negative impact on the human health and their surroundings. From Agricultural fields they come into soil, air, and water and enter human body effecting body organs badly. Undoubtedly concentration of pesticides is increasing in the atmosphere day by day and therefore it is urgently required to develop a green pesticides and suitable methods for their removal from our environment.

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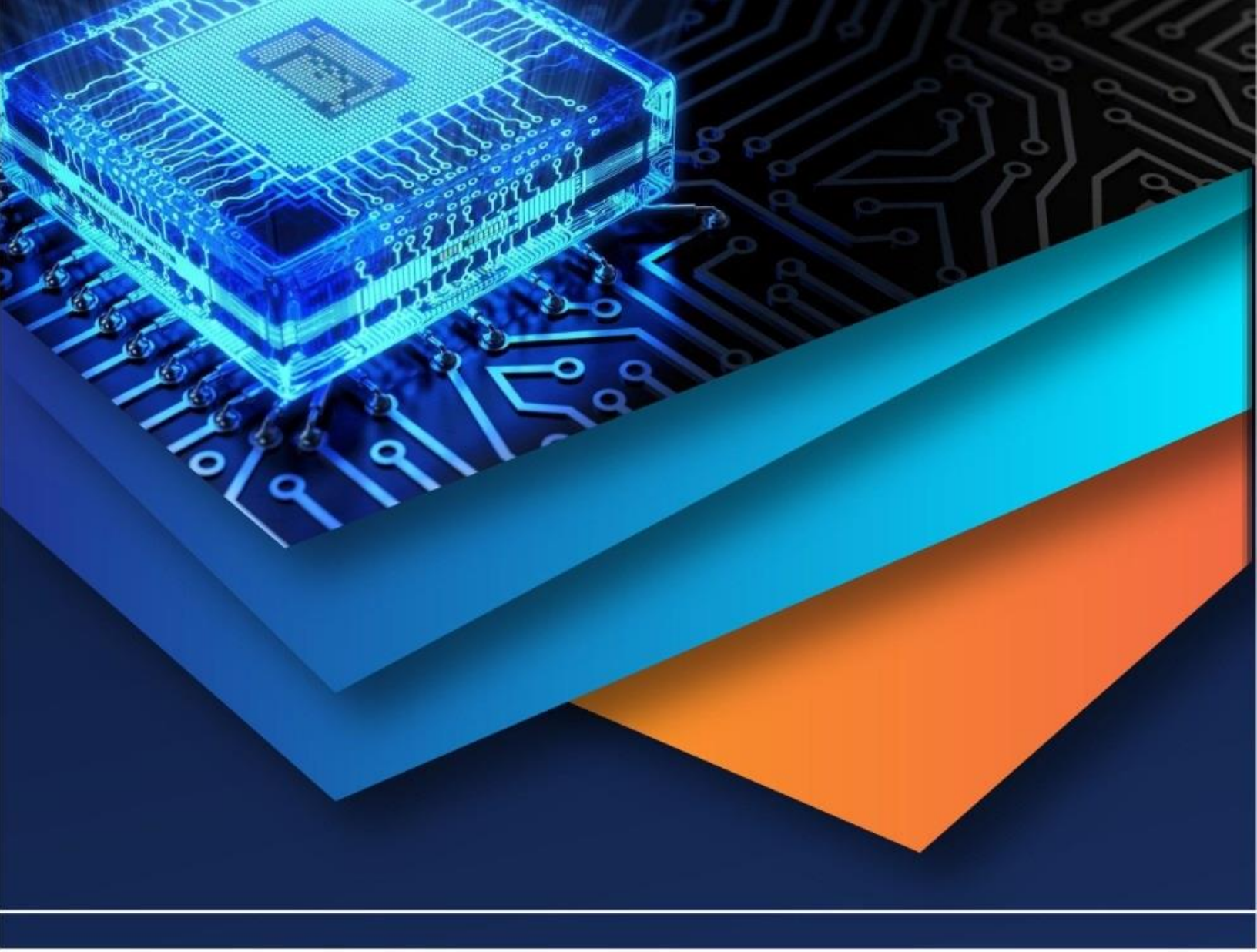

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