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REVIEW ARTICLE **OPEN ACCESS**

Pesticide Toxicity and Health Issues in Western Rajasthan: A Case Study of Bikaner District, Rajasthan (India)

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ABSTRACT
In all areas of crop production worldwide, pesticide use is increasing significantly. In order to increase production and quality as a result of the management of pests, weed or pest diseases, there are widespread use of chemical substances in agriculture. A significant proportion of the food production would have been spoiled if pesticides had not been applied. Each year, we could lose about one third of the world's crops. It is evident that pesticides are not only harming the environment but also affecting the food chain and health of farmers and humans, as a result of indiscriminate and excessive use. The present study is focused to investigate the relationship between pesticides and their impact on human health. Based on the preliminary surveys, there are eight major pesticides including Pendimethalin, Hexaconazole, Carbendazim, Mancozeb, Monocrotophos, Dimethoate, Chlorpyriphos and Emamectin benzoate being used in Bikaner region. The impacts of selected pesticides on human health were assessed for present investigation. It was noticed that the severity of health issues related to different pesticides were found in the order of Mancozeb > Carbendazim > Chlorpyriphos > Monocrotophos > Dimethoate > Emamectin Benzoate > Pendimethalin > Hexaconazole in various crops. It may be due to indiscriminate use, method of application, use of safety measures during spray of pesticides, lack of pesticide poisoning related knowledge among the farmers etc. The impacts of selected pesticides on human health were assessed for the present investigation.
Keywords: *Pesticides; agriculture crops; human health; diseases; environment.*

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INTRODUCTION

Agriculture is the primary source of food production. It provides different types of crops. Agriculture is the backbone of the Indian economy where the main occupation of people is agriculture. About 60-70% population of India are farmers and dependent on agriculture and cultivation. There are many challenges in agriculture sector, including pest infection, irregular rainfall patterns, floods etc. Farmers of Indian sub-continent is facing these issues every year. Farmers apply a large variety of pesticides to deal with the problem of pests. After the Green Revolution, pesticide applications have grown more rapid across India. Horticulture crops are most vulnerable from pest attack point of view. India accounts for only 3% of it's total area for fruits and vegetables production, while it consumes about 13-14% of total pesticide applications (1). The 1.65 billion to 7.7 billion population are increased throughout the twentieth century (2). According to United Nations report published in 2015, the universal population will rise up to year by year about 8.5 billion by 2030, 9.7 billion by 2050 and 10.9 billion by 2100. Food production needs to be boosted by a proportionate rate in order to meet the demand for increased production. About 15-25% of total food produced in India is destroyed by pests every year (3). In India, agriculture is mainly dependent on the arrival of the monsoon, which is very uncertain. Pesticides are integral part of agriculture because they play a key role on plant growth regulator, defoliant and desiccant (4). The excess and unjustified pesticide usage may result in severe health issues in living being including human. It can penetrate the soil layers and can reach to groundwater. It can also contaminate food chains. It may result in biodiversity losses and ecological imbalance. Pesticides used indiscriminately may contaminate the soil, water, and air around us. Pesticides include such chemicals as insecticides, herbicides, fungicides, acaricides and nematicides. Globally about 56% of herbicides, 19% of insecticides, 25% of fungicides and other pesticides are used. While in India about 51% of insecticides, 33% of fungicides, 16% of herbicides and use of additional insecticides (5). a large majority of pesticides kills the pest by interfering the vital metabolic process of projected parts (6).

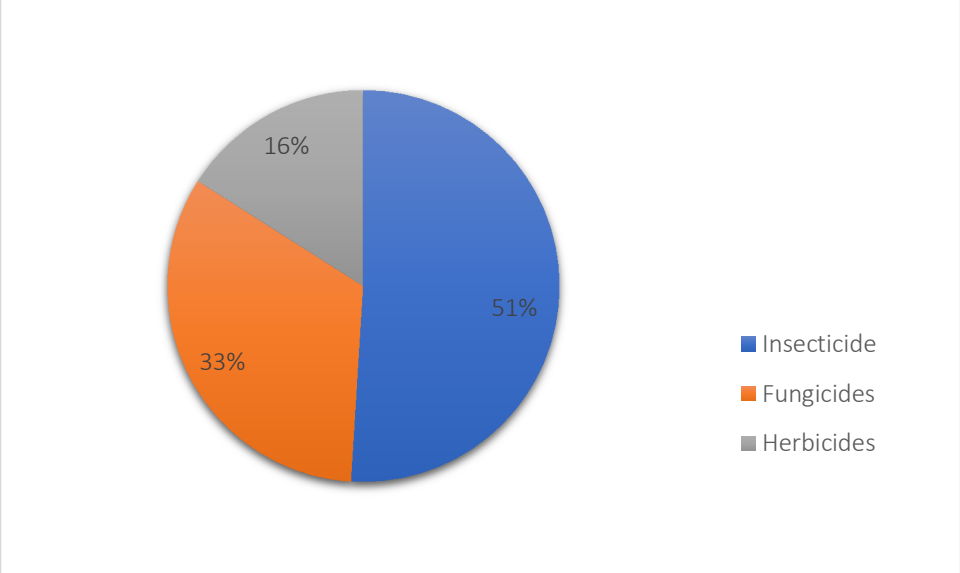

Figure 1: Category-wise Pesticide consumption by category in the Indian agriculture system [5, 9]

In India, it is very important to use pesticides in order to obtain a high yield variety for both Kharif and Rabi crops. Pesticides application is important for qualitative and quantitative production of cash crops especially *Gossypium herbaceum* and *Nicotiana tabacum* in Rajasthan (7). They found Rajasthan has a huge contribution in edible oils and oilseeds production as well largest in India. Between the oilseed crops, *Arachis hypogaea* and *Brassica nigra* are the most popular crops in India. They are at the forefront of the national edible oil economy. A valuable organic manure and animal feed is obtained from the oilcake that has been extracted. India, China, USA and West Africa are the world's largest growing *Arachis hypogaea* growing countries. As far as the world's land area and production of *Arachis hypogaea* are concerned, India has been at the top. It is grown in an area of 5.47 million hectares and produced 5.51 million tons in the year 2009-10 . Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Rajasthan and Uttar Pradesh are the main production states for *Arachis hypogaea. Arachis hypogaea* production in the nation comes from Rajasthan, which contributes roughly 3.77% of its area and 4.28% of its production. Rajasthan ranks fifth in productivity and sixth in area for the *Arachis hypogaea* crop, respectively. Similarly, *Brassica nigra* is the third most important edible oilseed crop in India after *Glycine max* and *Arachis hypogaea*. It is mainly used for its oil throughout Northern India. It is also used in the preparation of hair oils, medicines, and soap and mixed with mineral oils for lubrication and in the manufacture of grease. In India, it is grown on 6.45 million hectares, with an annual production of 6.82 million tonn during 2015-16. Rajasthan is a large producer of *Brassica nigras* in India, with an annual production of 3.37 million tons and an area of 2.38 million hectares in 2015-16. It contributes 49.4 percent in total production of the country. National and state productivity of *Brassica nigra* in 2015-16 were 1057 kg ha-1 and 1415 kg ha-1,. Rajasthan contributes about 50% production of *Brassica nigra* in the country (8). Major food crops cultivated in Bikaner district include; *Cyamopsis tetragonoloba*, *Brassica nigra*, *Cicer arietinum*, *Cuminum cyminum*, *Coriandrum sativum*, *Vigna radiata*, *Pennisetum glaucum*, *Triticum aestivum*, *Arachis hypogaea* and *Gossypium herbaceum*. *Arachis hypogaea* and *Brassica nigra* are the main crops grown in Rajasthan's Bikaner district, which is located in the north. To control numerous pests and boost crop productivity, pesticides are commonly used in Bikaner region are Pendimethalin, Mancozeb, Azoxystrobin, Difenoconazole, Hexaconazole, Carbendazim, Propiconazole, Thiophanate methyl, Thiamethoxam, Imidacloprid, Lambda cyhalothrin, Monocrotophos, Dimethoate, Chlorpyriphos and Emamectin benzoate. The preliminary survey during the present investigation revealed that Pendimethalin, Hexaconazole, Carbendazim, Mancozeb, Chlorpyriphos, Monocrotophos, Dimethoate and Emamectin Benzoate etc. are mostly used pesticides for *Arachis hypogaea* and *Brassica nigra* crops in the region. Seasonal variation of pesticides. The use of pesticides was shown on the crops Different time periods for various times purposes in agriculture. It is crucial to determine the seriousness of the pesticide residue issue in the Bikaner district given the widespread application of pesticides and its consequences for human health.

IMPORTANCE OF PESTICIDES IN PRESENT SCENARIO

Before the green revolution came in 1960's, the most popular commercial pesticides designed to fight against this pest problem were arsenical compounds (discovered in 1867), lime Sulphur (in 1880), 2,4-D (in 1885), lead arsenate (in 1892), thiram (in 1931) and DDT (in 1939). The total quantity of pesticides usage each year are approx. 500 million kg, which in agriculture about 70% was used and 30% by government agencies and the public (9). The global pesticide consumption in 2019 came to about 4.19 million metric tons, of which China was the world's largest pesticide consumers with 1.76 million tons, the United States is 408 thousand tons, Brazil is 377 thousand tons and Argentina is 204000 tons (kt) (10). In Asia, India is the leading producer of pesticides. India had been producing 90 thousand tons of organochlorine, benzene hexachloride and DDT per year (11). With an average annual usage of 2.784 kg ha1, the cost/benefit ratio between 2010 and 2014 was 0.645 g of total pesticides per kilogram of crop production. Between 2010 and 2014, Japan had the highest average pesticide consumption (18.94 kg/ha), while India had the lowest (0.26 kg/ha) (12). There is widespread use of pesticides in controlling vector-borne diseases like malaria, filariasis, dengue, chikungunya etc. The government of India started National Malaria Eradication Programme (NMEP) in 1958, which was mainly driven by application of DDT. To protect crops from pests the application of a wide variety of pesticides became popular after the green revolution in 1967-1968 (13). The initial results of pesticides spray were excellent. They had boosted the crop production, as well as helped in controlling vector borne diseases in human and animals (14). The ill effects of such pesticides were coming into notice after publication of historic book "The silent spring" (Rachel Carson, 1962). Pesticides have been detected in groundwater (15), surface water (16), mother breast milk (17), milk and milk products (18), honey bee (19), ambient air (20), vegetables (19), fruits and soil samples (20). They analyzed 777 samples of cereals in (*Hordeum vulgare* and *Triticum aestivum*), fruits and vegetables. Pesticides are also affected primary producers and macro-invertebrates (22). A total of 76 pesticides like pyrethroids, organophosphate, carbamates and other pesticides active ingredients were found to be use in vegetables in Kuwait. 9% of these belong to the WHO toxicity class lb found which is very hazardous (23). They analyzed that the majority of the farmers recognized pesticides produce risk to the environment (65%) and human health (70.5%). They also assessed that younger farmers were more recognized pesticide pose risk compare to the older farmers.

PESTICIDES AND ENVIRONMENT

Pesticides are broadly used in modern agriculture. It is effective and economical way to enhance the crop yield quality and quantity (24). Without pesticide application, more than half of our crops would be lost due to pests and diseases. The losses in crop yield can be reduced by applying suitable number of appropriate pesticides, which simultaneously reduce financial losses to the farmers (25). The losses to crop preventing due to insects and other pests, pesticides can save farmers money and return on the money they spend on it (26). Weeds are another suppressor of crop yield. It is observed that weeds may reduce about 37-79% of crop production. The application of suitable pesticides may reduce the crop losses from weeds by 48-28% (27). A ban on some pesticide in U.S. has resulted in a rise in food *Oryza sativa*s as a result of employment losses. With the help of pesticide application, farmer grow more food on the same piece of land (28). Pesticides play as a transformer that fills in as obliterating bug (29). Insecticides also Improve the state of hygiene at home Keeping the bugs' population under control (30). Through control of rodents and insect vectors, pesticides prevent the occurrence of disease outbreaks which contribute to improved human health. Deaths of about seven million people all around the world have been prevented through insecticide mediated killing of disease vectors. The malaria control which accounted for an average of 5000 deaths per day is the most important example (31). By suppressing weeds and preventing the structural damage resulting from an infestation of termites, pesticides will also contribute to maintaining the beauty of parks. To protect the field, playground and golf course, pesticides and insecticides are used (32).

PESTICIDE POISONING AND MORTALITY

In India, about 100 people were died due to consumption of *Triticum aestivum* flour contaminated by parathion was reported in 1958 in Kerala (33). This was the first reported incident in the country. Similar incidents were also reported from different parts of the country by various researchers (34,35). According to WHO reports there are about 7,50,000 instances of pesticide poisoning reported every year throughout the world, out of which about 13,800 deaths occur due to such incidents (36). The pesticide poisoning incidents were reported from Malwa region in 2001-2002 (37). The study revealed that about 21% of deaths occurred due to pesticide poisoning were reported during June month, while it was lowest 2% in September month. Similar study was conducted by (38), who reported 61 deaths in Bathinda district of Punjab, during 2004-2008 due to pesticide poisoning poor knowledge of pesticide applications, lack of personal protection equipment during spraying of pesticides, high rate of illiteracy in rural areas, lack of training on effective handling of pesticides etc. were major curse of the high mortality rate farmers in Punjab (39). Among all categories of pesticides, the Organophosphorus toxicity is most common in India. It

may be due to low cost, easy availability and broad-spectrum application of such pesticides (40) In order to explain the correlation between two sets of data, (41) defined as canonical correlation analysis. Positive associations between the use of agricultural pesticides and their impact on health risk have been identified. They looked at mortality rates for children under the age of five per 1,000 live births, lung cancer (dalys/1000 capita) per year, asthma (dalys/1000 capita), chronic obstructive pulmonary disease (COPD), respiratory infections (dalys/1000 capita), and cardiovascular disease (dalys/1000 capita).

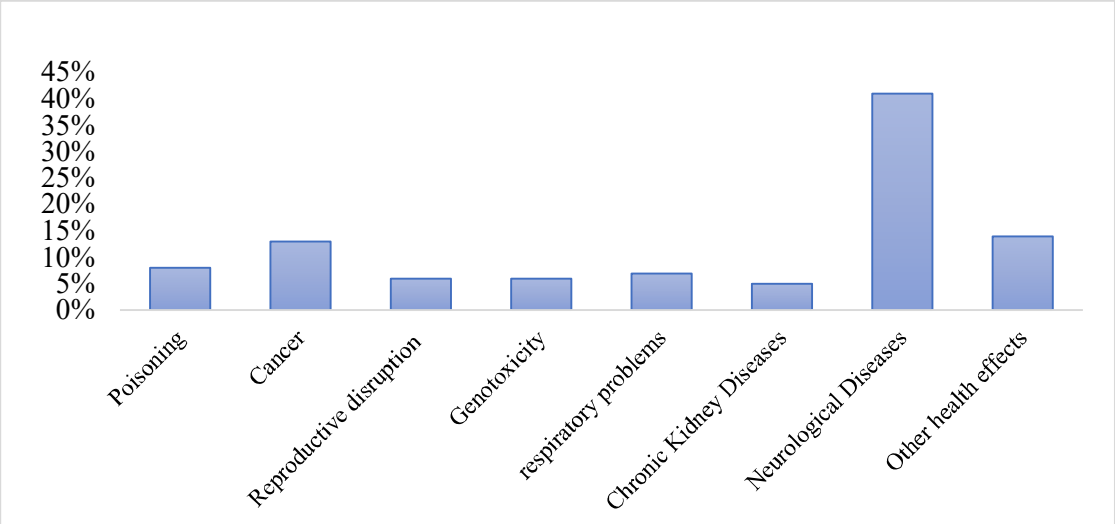

Figure 2: The effects of pesticides on human health [4].

Table 1: - Commonly used pesticides in Bikaner and their possible the effects of pesticides on human health

S. No.	Pesticides and it's category	Commonly applied in Crops	System affected	Common symptoms	References
1	Pendimethalin (Herbicide)	*Triticum aestivum*, *Oryza sativa*, *Gossypium herbaceum*, *Glycine max*, *Arachis hypogaea*, *Cicer arietinum*, *Brassica nigra*	Brain, spinal cord, nervous system, skin, eye, stomach and intestine	Headache, giddiness, nausea, vomiting, sweating, confusion, excessive lacrimation and salivation may occur	(42;43)
2	Mancozeb (Fungicide)	*Arachis hypogaea*, *Oryza sativa*, *Zea mays*, *Cuminum cyminum*, *Solanum tuberosum*, *Solanum lycopersicum*, *Malus pumila*	Brain, spinal cord, nervous system, skin, eye, stomach, intestine, ovaries, testes, fetus, nose, lung and trachea	Headache, lethargy, coughing, sneezing, itching, vomiting, hypothermia, ataxia, infertility, miscarriage and cancer may occur	(44;45)
3	Hexaconazole (Fungicide)	*Arachis hypogaea*, *Phaseolus vulgaris*, *Mangifera indica*, *Oryza sativa*, *Vitis vinifera*	Brain, spinal cord, nervous system, skin, eye, stomach and intestine	Nervousness, anxiety, tumor, convulsions and allergic manifestation may occur	(46;47)
4	Carbendazime (Fungicide)	*Oryza sativa*, *Arachis hypogaea*, *Solanum tuberosum*, *Camellia sinensis*, *Phaseolus vulgaris*	Brain, spinal cord, nervous system, ovaries, testes, fetus, nose, lungs and trachea	Sweating, headache, lethargy, vomiting and cancer may occur	(48;49)

5	Monocrotophos (Insecticide)	*Oryza sativa*, *Brassica nigra*, *Cicer arietinum*, *Gossypium herbaceum*, *Mangifera indica*, *Coffea arabica*, *Cucumis sativus*	Brain, spinal cord, nervous system, ovaries, testes and fetus	Headache, giddiness, vertigo, blurred vision, excessive lacrimation, salivation, infertility and miscarriage may occur	(50;51)
6	Dimethoate (Insecticide)	*Arachis hypogaea*, *Brassica nigra*, *Cyamopsis tetragonoloba*, *Allium cepa*, *Solanum tuberosum*, *Solanum lycopersicum*, *Malus pumila*, *Abelmoschus esculentus*, *Brassica oleracea*, *Capsicum annuum*	Brain, spinal cord, nervous system, stomach and intestine	Headache, giddiness, vertigo, diarrhea and convulsions may occur	(52)
7	Chlorpyriphos (Insecticide)	*Oryza sativa*, *Brassica nigra*, *Cicer arietinum*, *Gossypium herbaceum*, *Arachis hypogaea*, *Solanum melongena*, *Abelmoschus esculentus*, *Brassica oleracea*, *Brassica oleracea var. botrytis*, *Allium cepa*, *Solanum tuberosum*, *Malus pumila*, *Vitis vinifera*	Brain, spinal cord, nervous system, stomach, intestine, ovaries, testes, fetus, nose, lungs and trachea	Headache, dizziness weakness, vomiting and sensation of tightness in the chest and cancer may occur	53;54)
8	Emamectin Benzoate (Insecticide)	*Gossypium herbaceum*, *Arachis hypogaea*, *Abelmoschus esculentus*, *Oryza sativa*	Brain, spinal cord, nervous system, skin, eye	Dilation of pupils, muscular incoordination, ataxia and muscle tremors may occur	(55;56)

MITIGATION MEASURES AND RECOMMENDATIONS

Based on the findings, recommendations for mitigating the risks associated with pesticide residues in Bikaner district are proposed. These include the adoption of integrated pest management practices (Implementing a combination of biological, cultural and chemical methods to control pests), promoting organic farming (Adopting farming practices that avoid synthetic pesticides and promote soil health) and enhancing awareness among farmers about the justified use of pesticides. Furthermore, the development of effective monitoring systems and regulations for pesticide residues is necessary to ensure the safety and well-being of the population and the environment.

CONCLUSION

It has been observed that synthetic pesticides have contaminated every component of the environment including soil, water, air, food materials, milk, honey, fruits and vegetables etc. The adverse impacts of such pesticides may cause severe health-related issues in living beings including humans. The highlights of the present investigation revealed that better management of pesticide usage in the region is the need of the time and the development of strategies to reduce the potential risks to human health and the environment must be taken seriously to mitigate the adverse impacts of such notorious chemicals. The present study

was focused on the environmental effects of eight major pesticides commonly used in the Bikaner division. The study was also targeted to generate awareness of the pesticide residue problem in the study area. The data of the last two decades regarding pesticide exposure and human health revealed that several pesticides cause neurological disorders and degenerative diseases. Pesticides exert a significant effect on growth and may cause inherited anomalies and carcinogenic effects on human.

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