

PESTICIDES; A NECESSARY EVIL IN THE AGRICULTURAL VALUE CHAIN- A REVIEW

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ABSTRACT

Even though pesticides constitute a very essential component of improved and modern agriculture, the abuse of pesticides has brought substantial poisoning worldwide, especially in developing countries. This review investigates the possible sources by which people are exposed to pesticides worldwide and the impact on their livelihood. The group who often are exposed to these chemicals includes, farm workers, children, farmers, and family members who have direct link to the pesticide application sites as well as

persons who are exposed to these pesticides through the domestic use of waterbodies and consumption of foodstuff or crops sprayed with these pesticides. Central to this review is the critical discussions of the different scientific research findings on health effects and risks related to pesticides usage. Again, organophosphates and organochlorines pesticides are found in most of the pesticide contaminated sites and can remain in soil and waterbodies for a longtime. This work has also provided cases of incidence of carcinogenicity in humans, as a result of pesticides use. We concluded that, breeding or developing insect tolerant or resistant crops may curb the profuse use of pesticides in agriculture.

Keywords: Pesticides, carcinogenic, pesticides production and exposure, pesticides use.

INTRODUCTION

There are a wide range of pesticides used all over the world. Synthetic pesticides introduction between the 1960s and 1980s contributed immensely to pest control in agriculture and as a result, improved agricultural productivity. Preferably, a pesticide should be toxic to the targeted organism, but not to untargeted environment, organisms or species, including humans (Zahm & Ward, 1998).

Pesticides are commonly used in agriculture. They destroy undesirable agents such as weeds, insects and fungi that destroy particular crops and reduce their multiplication. It is also used on water bodies to kill bellicose to plants and control growth algae. Common pesticides used in

the world are grouped according to the organisms used on and chemical composition. Their groupings include insecticides, rodenticides, fungicides, herbicides and avicides. They are chemically classified as pyrethrin, organochlorines, organophosphates, pyrethroids, carbamates and arsenals compounds (Kariathi, Kassim, & Kimanya, 2016). A research by Zhang (2018), show that globally, the use of other pesticides accounted for the most proportion of total pesticides (53.84%), seconded by herbicides (25.10%), and followed by fungicides & bactericides (12.06%), insecticides (7.50%), plant growth regulators (1.24%) (Figure 1). Farmers are able to ensure good returns on their investment by using pesticides. Korir, reported that farmers gain four-time return in crop production on pesticide investments (Korir, 2011). However, the negative aftermath of pesticides usage is numerous. About 98% of pesticides sprayed reach destinations other than their intended target (Sharma, Thapa, Manandhar, Shrestha, & Pradhan, 2012). Consequently, it has become toxins of water, air, soil and human

health. Indeed, many are found to be highly carcinogenic in animals and humans bioassays. In a study by the National Toxicology Program and the National Cancer Institute, in the USA, on fifty-one pesticides showed that twenty-four were carcinogenic in bioassays (Blair, Dosemeci, & Heineman, 1990). Again, the International Agency for Research on Cancer (IARC) of the World Health Organization recorded twenty-six pesticides as possessing enough evidence of carcinogenicity in animals and nineteen as having partial proof in animals (International Agency for Research on Cancer [IARC], 1999). People living, working or attending school around or closer to larger farms are at very high risk to pesticide drift, especially those who use raised equipment for spraying or crop duster planes to spray pesticides on crops. The most vulnerable actors to these airborne pesticides are children, because their bodies and organs are still under development. Sprayed pesticides drift and settle on toys, laundry, play areas, porches, pools, furniture and many more where people easily get in contact with.

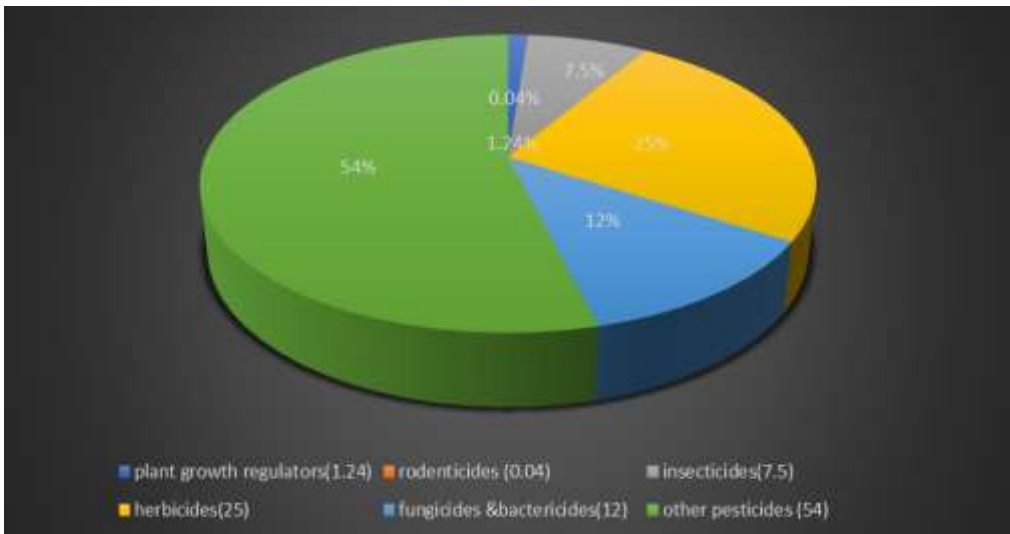


Figure 1: Proportion of Global pesticide use profile (Zhang, 2018; Gunnell, Eddleston, Phillips, & Konradsen, 2007; Liu, Pan, & Li, 2015).

PESTICIDE AND CROP PRODUCTION

There are approximately nine thousand species of insects and mites, about fifty thousand species of pathogens associated with plant, and eight thousand species of weeds that harms crop worldwide (Zhang, Jiang, & Ou, 2011); Pimentel, Lach, Zuniga, & Morrison, 2002). Pesticide has become very important to farm productivity and is estimated that about one-third of products from agriculture are produced using pesticides (Zhang et al., 2011; Liu et al., 2015). Cai et al., reported that without the use of pesticides the damage of fruits, vegetables and cereal would have increase by 54%, 32% and 78% respectively (Cai, Mo, Wu, Katsoyiannis, & Zeng, 2008). In the U.S, fungicides are used to produce about 80% of their fruit and vegetables. Again, crop loss caused by pest invasion declined from 35% - 42%. In 2007 alone, the global production value of apple increases by One thousand two hundred and twenty-three million US dollars by using fungicides (Guo, Schnieder, & Verreet, 2007). Zhang et al., confirmed that without pesticide use, cotton, soybean and wheat export would have decrease in the United States by about 27% (Zhang et al., 2011). However, there are record of high rate of pesticide overuse and pollution as well (Liu, et al., 2017; Liu et al., 2008). In Africa, agrochemical such as pesticides are subsidized or provided freely by the government to farmers, especially those producing cash crops to help crops at high quantity and good state to help boast the country economy. In Côte d'Ivoire, for instance, insecticides were given to cotton farmers free at critical times of the country economy (1966-1994) (Ajayi, 2000). In most countries in the sub Saharan Africa, pesticides are sometimes provided freely to farmers for use on cereal and legume staples to control of pests and disease outbreak such as locusts, armyworm, quelea birds and many more (Williamson, 2003).

WORLDWIDE PESTICIDE PRODUCTION AND USE

Technical grade pesticides production had grown steadily worldwide, especially in the China, Germany, USA, France and India (Table 1). Globally, about £5billion of pesticides are used per annum, among which organophosphate and carbamate insecticides (34%), phenoxy herbicides (12%) and dithiocarbonate fungicides (18%) are the most frequently applied (Ye et al., 2013). China is known to be the top producer and consumers of pesticides in the world (Table 1 and 2). Greenpeace in 2013, reported that in China about 70% of pesticide sprayed to maintain plants, leach into the soil and groundwater. Recently, the government reported that pesticide use by farmers in China had thrice the universal average (Liu et al., 2017). Zhang et al., reported that insecticides, rodenticides, and herbicides usage in the country accounted for 17.05% of pesticide poisoning (Zhang et al., 2011). In India, pesticides demand in relations to price was estimated to be around 0.5 billion dollars (2% of the total world market). The form of pesticide usage has taken a different trend in India. Even though India is among the leading pesticides producers in the world, herbicides and fungicides are not often used as much as insecticides (Aktar, Senguptam, & Chowdhury, 2009). About 45% pesticides use in India is for production of cotton, then wheat and paddy (Aktar et al., 2009). Globally, pesticides consumption has increased significantly, in the United States for example, the pesticides usage doubled from 1960 to 1980, but overall use has remained stable since then (United State Environmental Protection Agency [USEPA], 2001). This is because of the institution that has been set up to check it production and consumption. In the United States, most pesticides used aim to enhance agriculture productivity, but in 1999 a lot of households (about 74%) were reported to use at least one or more pesticide in the home (USEPA, 2001).

The use of pesticide has increased in most low- and middle-income countries. Some of the wildest growing markets

includes South and Central America, Asia, Africa. Pesticide use on crops grown for export are used highly in some countries in this continent. Thailand and Bangladesh have quadrupled their pesticide use since the 90s, whereas Burkina Faso, Ghana and Ethiopia have recorded a tenfold increase over the same period, even though new to the game. Most pesticides are imported by developing countries from developed

countries where they arrive somethings pre-formulated or formulated locally from their raw forms (Mrema, Ngowi, & Kishinhi, 2017). The annual imports of pesticides in African countries like Sudan is approximately 5000 metric tons, of which 88% are used in agriculture (cotton, vegetables and sugarcane), 7% in pests' control and 2% in the public health sector per annum (Abdelbagi et al., 2018).

Table 1: Global production and export of pesticide in 2017. (Zhang, 2018; Jin, Wang, He, & Gong, 2017; Ives, 2017)

Country	Production and export of pesticides
China	\$4.8 billion (14% of total export)
Germany	\$4.2 billion (12.4% of total export)
United States	\$3.9 billion (11.5% of total export)
France	\$3.5 billion (10.4% of total export)
Belgium	\$2 billion (6% of total export)
India	\$1.8 billion (5.3% of total export)
Israel	\$1.31 billion (3.9% of total export)
Spain	\$1.3 billion (3.8% of total export)
United Kingdom	\$1.28 billion (3.8% of total export)
Italy	\$756.6 million (2.2% of total export)
Netherlands	\$722.5 million (2.1% of total export)
Hungary	\$622 million (1.8% of total export)
Japan	\$517 million (1.5% of total export)
Singapore	\$483.9 million (1.4% of total export)
South Korea	\$421.4 million (1.2% of total export)

Table 2: Global Pesticide Consumption (Pretty & Bharucha, 2015; Zhang et al., 2011; Liu et al., 2015)

Top Rank	Country	Pesticide Consumption per year (millions of kilograms)
1st	China	1,806
2nd	United States	386
3rd	Argentina	265
4th	Thailand	87
5th	Brazil	76
6th	Italy	63
7th	France	62
8th	Canada	54
9th	Japan	52
10th	India	40

SOURCES OF PESTICIDE EXPOSURE

Pesticides exposure happens in numerous ways. It may occur in farming, through the spraying of crops or treatment of harvested grain for storage. Pesticides exposure also occur in gardening, forestry, professional and domestic pest control of

facilities such as playgrounds, our parks and around our buildings. Exposure also ensue through woods and boat hull treatment with preservative and livestock (example Sheep dip) treatment with anti-fouling and anti-parasitic agents. Also, pesticide residues in or on our food

also puts us at very high risk. Humans and animals living close or around pesticide sprayed croplands can be highly exposed through application drift, over-spray, or off-grassing. Shoes, clothes and even pets which traps a lot of dusts loaded with pesticides are major source of exposure at homes (Simcox, Fenske, Wolz, Lee, & Kalman, 1995; Carnann, 1995; Nigg et al., 1990). Farmers often brings pesticides into the house on their dress and even equipment. Children, who are found often playing on the ground and always putting objects and hands in their mouths (Carnann, 1995), may be at very high risk of exposure. Contaminated surface and ground water from agricultural runoff are also source of exposure. It is reported that, about 50 million people in the United States of America obtain their drinking water from groundwater that is possibly polluted by pesticides and other chemicals used in agricultural (Nielsen & Lee 1987). Moreover, a national pesticide survey of drinking water by the United State Environmental Protection Agency (USEPA), found one or more pesticides in 4.2% of domestic wells in rural areas and 10.4% of water systems in the communities (Ministries, Bullard, Mohai, Saha, & Wright, 2007). Conventional techniques of treating drinking water are normally not aimed at removing the pesticide contaminants. For instance, a study in 1994 to examine five herbicides in two thousand samples from tap water and other sources of drinking water found that, about 14.1 million people in America regularly drink water contaminated with chemicals like metazachlor, simazine, atrazine, cyanazine, and alachlor (Wiles, Cohen, Campbell, & Elderkin, 1994). Another survey done in 1995 by the same organization also found an extensive herbicides contaminated tap waters, at levels beyond the USEPA lifetime health advisory levels (Cohen, Wiles, Bondoc, 1995). Research shows that pesticides are able to remain in the groundwater for a very longtime (Fenner, Canonica, Wackett, & Elsner, 2013). For example, it was reported that dibromochloropropane, was a fumigant

which was banned for use since 1977 in California, is still reported to be found in significant concentrations in the groundwater of the country after more than 19 years (Kloos 1996). Goolsby et al., reported high concentrations of acetanilide and triazine herbicides in rainfall during summer in America (Goolsby, Thurman, Pomes, Meyer, & Battaglin, 1997).

Although diet is known not to be a key route of exposure for most pesticides, occasionally some food items are recorded to have some residues. Hamilton & Crossley, reported in a research that some potatoes had lethal levels of aldicarb (Hamilton & Crossley, 2004). National Research Council in 2003, reported that there is high exposure of pesticide to children, who mostly consume more fruits than adults, because their immature metabolism and other factors makes them sensitive to the toxic effects (National Research Council [RNC], 2003). Another report by Willes et al., showed that in every four times a 5-year-old child or less consumes a peach, in one of the times he or she is likely to be exposed to organophosphate insecticide at a hazardous level (Wiles, Davis, & Campbell, 1998). Again, in a survey of 76 jars of baby food from some grocery stores found about 16 pesticides in eight samples.

There are many reports indicating the pesticides use in many countries in African, which includes Tanzania, Ghana, Niger, Algeria, Kenya, Ethiopia, Uganda, Malawi, South Africa and Morocco (World Health Organization, [WHO], 2010). In these countries' pesticide use is not only for cash crops, they are used a lot during the cultivation of non-cash crops like fruits, tubers, grains, vegetables, and other staple foods (Sheahan & Barrett, 2014)

In 1958, Nigeria reported the first event of human exposure to pesticides, where the family of a prominent cocoa farmer in a town called Okebode, (in western Nigeria) were hospitalized after consuming leaves which were earlier in the week sprayed with Lindane (Erhunmwunse, Dirisu, & Olomukoro, 2012). Again in 2004, twenty-

three cases of vomiting and death were recorded among people who ate noodles mass-produced in Nigeria, found to have residues of carbofuran pesticides (Erhunmwunse et al., 2012).

Contamination of lands, wildlife, aquatic bodies, blood, mother's breast milk and foodstuff by organochlorines pesticides in Nigeria and other countries in Africa has been proven (Osibanjo & Adeyeye, 1995; Erhunmwunse et al., 2012). There are also serious concerns about chemicals or pesticides used in storing grains in West Africa. Farmers and food companies are found of using pesticides to store foodstuffs to prevent destruction by insects. In Nigeria, there are several reports by the media of the use dichlorvos (well known as sniper), cyhalothrin, trichlorphon, chlorpyrifos, omethoate and dimethoate sprayed over grains (e.g. beans and maize) to preserve them from insects for 6 months or more. This is twice a burden of pesticide poisoning crops.

In Ghana, agriculture contributing to over 50% of the country's GDP (Breisinger, Diao, & Thurlow, 2008; Aryee, 2001). A research conducted in some farming areas in the Eastern region of the country showed that, 71% (1040 out of 1455) of heads of household reported to have used pesticides on either on their farms or in their homes, most commonly for control of weeds (1003/1040) or insects (888/1040). A lot of households (721 out of 1040) reported women helped in the spraying pesticides. Of these women, 366 out of 721 did so with their babies on their back. Only a few 301/1040 of those who sprayed worn protective devices when applying the pesticides. Regular symptoms that were reported after spraying, included difficulty in breathing (278 out of 1040), cough (336 out of 1040), and skin irritation (406 out of 1040).

CARCINOGENIC IMPACT OF PESTICIDES ON HEALTH

Although pesticides actually help farmers boost productivity significantly, it negatively affects human health and

surrounding environment. Millions of instances of pesticide poisonings are reported annually worldwide (Table 3). Pesticides are often able to make their way into pond, rivers or even oceans when sprayed on land. Water bodies polluted with pesticides, kills fishes and other animals. Hence, can toss the whole ecosystem off stability. Groundwater are also be affected by pesticides by a process known as seeping. Humans depend on groundwater and other water bodies for domestic activities such as drinking. Yet, if these water bodies are contaminated with pesticides, it is unhygienic and detrimental for the people to drink (Johnson, Domagalski, & Saleh. 2011). Moreover, pesticides are not only perilous to the environment, but they are also carcinogenic to a person's health. Studies had made us understand that pesticides have substantial long-lasting effects on health, such as neurological effects, cancer, respiratory diseases and even diabetes, fetal diseases and genetic disorders. There have been numerous reported cases of the impact of pesticides on livelihood all over the world (Table 3). Although developing countries are reported to use less than 30% of the pesticides in the world, they experience almost 99% of pesticides caused deaths. This is because there is more intense usage of pesticides in an unsafe manner and there are no structured regulatory and educational systems to check the use of these pesticides in these countries. Several instances of misuse and over-use on food crops have been reported with the associated negative effects on human health and productivity, (Amoako, Kumah, & Appiah, 2012). According to UN report 2017, it is reported that the cost of pesticides carcinogenicity in Africa is about \$90bn.

There are several reports of pesticide associated ill- health among actors in the agriculture value chain. For instance, Williamson et al., in a study, described endosulfan, cyhalothrin, chlorpyrifos and lambda being associated with cases of ill-health among farmers in Ghana (Williamson, Ball, & Pretty, 2008). Ntow also detected lindane and endosulfan in

water bodies in the area of rigorous tomato farming, while in other farms organochlorine residues were also found in sediment of streams (Ntow, 2001). A very similar outcomes were reported in a study at the Volta Lake of Ghana (Ntow, 2001). A study to evaluate the remains of pesticide in some foods collected from twelve states in India, 82% of DDT residues were found in two thousand two hundred and five samples of bovine milk collected from twelve states. Thus, about 37% of the samples had DDT remains above the tolerance levels of 0.05 mg/kg. The study by Zhang et al., found organophosphorus pesticides as highly

carcinogenic to human health, and accounted for about 86% of the whole cases studied (Zhang et al., 2011). Another study in Eastern China found about three thousand children poisoned by pesticides in the farming seasons between 2006 and 2015 (Fan, 2017). Ferreira et al., reported a five-year study on indirect pesticide exposure and cancer risks on farmers' family members or people living in rural areas where there is an intensive use of pesticides, showed evidence with increased risk of leukemia in childhood in five studies (Ferreira et al., 2013) (Table 3).

Table 3: Cases of carcinogenic impact of pesticides on livelihood of some actors in the agriculture value chain

Cases	Findings	Reference
01	The reports showed a very substantial role of the nucleotide excision repair in the high risk of prostate cancer due to exposure to fonofos and carbofuran pesticide among male who apply white pesticide on farms.	(Barry, & Edgman-Levitan, 2012)
02	Pesticide use and obesity were reported to be linked with high risk of cancer. A research conducted among 67, 947 men and women in North Carolina and Iowa suggested that certain pesticides may alter obesity effects on the risks of lung and colon cancer.	(Lerro et al., 2015)
03	The report of a research conducted in thirteen Brazilian states suggested that, exposure to pesticide during pregnancy may cause the etiology of acute lymphoid and myeloid leukemia in children under 1 years of age.	(Ferreira et al., 2013)
04	A research conducted among children of pesticides applicators showed high risk of cancers including all lymphomas and Hodgkin's lymphoma. Increased risk of cancer is detected among 17, 357 children whose fathers do not use chemically resistant gloves	(Flower et al., 2004)
05	This research reported that small scale female farmers in West Sumatran apply pesticides without protection in a highly insecure way. They reported symptoms of burning nose, sore throat, muscle cramps, nausea, and constipation eye burning dizziness, blurred vision and shortness of breath. They realized that these were as a result of the number of hazardous pesticide products that are handled on a weekly basis, especially during continuous growing seasons.	(Murphy, Cuneo, & Bedford, 2004)

CONCLUSION

Indeed, pesticides potentially help boost agriculture productivity significantly worldwide. But its health implication is absurd. The way of the usage of these chemicals, especially in Africa, negatively

incur risks on the health of humans and their environment. Hence, diminishing net growth in productivity and well-being in the long run. We found that commercial pesticide formulations also may pose a carcinogenic risk to human health. Overuse,

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misuse and lack of appropriate precaution and protection during the application of these pesticides account for high health risk. In Africa, the lack of proper regulation and checks on imports of these chemicals have caused a high impact on ill-health. Our review has also proved that many carcinogenic ill-health results are ambiguous; some research reports also show that many of the health outcomes results on the carcinogenicity of pesticides are uncertain; some studies find exposure to pesticides leading to cancer, whereas others do not. Others even report its causing diabetes and many more. Yet, on the bases of our review, we will conclude that even though much research has not proven the carcinogenicity of pesticide in Africa, the few reports should make us very aware, cautious and careful in taking precaution when dealing with these chemicals. Again, breeding or developing pest-resistant or tolerant crops may curb the profuse use of pesticides in agriculture.

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