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PESTICIDES USE AND HEALTH IN NIGERIA

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ABSTRACT

This review addresses pertinent environment-health issues related to the use of (synthetic) chemical pesticides, in agriculture and general household in Nigeria. It examines factors responsible for the well-cited data that 99% of the deaths associated with pesticides occur in developing countries like Nigeria, where only 25% of the world's production of pesticides is used. Such factors identified include: poor pesticide education leading to extensive misuse; issues with correct, effective, and safe applications of pesticides; the use of the cheaper but deadliest types of pesticides (in terms of persistence and toxicity); poor legislation and lack of enforcement of available legislation; lack of adequate information, knowledge, and awareness of the inherent dangers of pesticides; lack of training on correct handling of pesticides at home; absence of monitoring for pesticides residues on locally-consumed products, unlike the situation for products meant for export; and inadequacies in medical recognition and responses to pesticide poisoning. Other problems and issues associated with the use of pesticides were also examined. These include disruption of Ecological Balance and Collapse of Biodiversity; Unsustainable Chemical reliance; Pesticide Resistance; and **e**conomic issues. Solutions to ameliorate the situation were suggested. These include more public education, more intensive promotion of the Integrated Pest Management Scheme, green technology, and adoption of food irradiation by gamma rays to extend shelf lives of agricultural products.

Key words: Pesticides. Health Impacts.

INTRODUCTION:

The recent "tomato ebola" in Nigeria is a vivid demonstration of the importance of pesticides in modern day agricultural practice [The Guardian 2016]. Without pesticides, unimaginable loss of products could occur while we helplessly look on. However, also quite troubling are the health hazards these pesticides could pose to people. They could also have severe adverse impacts on the ecosystem and economy, particularly as we are compelled to use more and more of them as they lose potency and effectiveness over time.

India is one classic example of catastrophic consequences that could attend uncritical use of pesticides. In addition to well-documented severe impacts of the pesticide endosulphan on people, particularly children [TERI, 2004], there is also the incredible number of 300,000 debt-ridden farmers resorting to suicide, in the space of fifteen years, in a bid to escape multi-faceted problems associated with the use of pesticides, particularly in the genetically-modified cotton industry in that country [CHRGJ. 2011].

Several responsible bodies and organizations are taking the initiative to ensure safe use of pesticides in Nigeria. Government agencies such as National Environmental Standards and Regulations Enforcement Agency (NESREA), National Agency for Foods and Drugs Control (NAFDAC), the Cocoa Research Institute of Nigeria (CRIN), the Nigeria Stored Products Research Institute (NSPRI), etc, are at the fore-front of translating research findings to regulations and communicating these to the nation through various workshops. There are also private organizations such as the Pest Control Association of Nigeria (PECAN) and the West African Agricultural and Productivity Programme (WAAPP-Nigeria) working to ensure safe use of pesticides in Nigeria.

However most of these bodies address, largely, organized groups of stakeholders such as farmers' groups, pesticide marketers, etc, whereas, in Nigeria, virtually every other person is a farmer of sort, with backyard vegetable farms, poultry, or fish ponds, etc. Moreover, there is probably no home where some pesticides are not used to control soldier ants, mosquitoes, cockroaches, termites, rats, etc. There is therefore the need for

mass education of the general public if we are to effectively address the issues involved in pesticide use, misuse, and abuse in the country. This review addresses pertinent environment-health issues related to the use of (synthetic) chemical pesticides, in agriculture and general household in Nigeria.

TYPES OF PESTICIDES AND THEIR APPLICATIONS

Pesticides are used all around us, in farms, homes, schools, gardens, and public parks. A comprehensive definition of pesticide will describe it as a chemical or biological agent that deters, incapacitates, kills, or otherwise discourages pests including vectors of human or animal disease, unwanted species of plants or animals, from causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of goods, agricultural commodities, wood and wood products. Pesticides could also be animal feed stuffs which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. [FAO 2006, Wikipedia 2016]

And what are pests? A pest can be defined as any animal or plant which harms or causes damage to man, his animals, crops, or possession. Agricultural pests include insects, mites, plant pathogens, and weeds; while household pests include cockroach, fleas, mosquitoes, termites, bedbugs, and rodents etc. Some pests occur perennially and could cause serious and persistent economic damage if not controlled, while some cause economic damages only on certain occasions, when there is disturbance in the ecosystem. Others migrate from one geographic zone to another under various environmental influences.

Pesticides therefore include insecticides (bug killers), herbicides (weed killers), and fungicides (fungus killers), rodenticides (rat killers) and antimicrobials. They are applied either on the farm or after harvest during storage at home, shops, or large food storage facilities. They could be used for curative purposes where broad-spectrum pesticides are applied to quickly remove, or minimize pest population; or in a Protectant Mode where pesticides are applied before the predicted infestation or attack of the pest. Pesticides could also be applied continuously as prophylactics, to prevent the expansion of pest populations. In Europe, pesticides used outside of agriculture are called biocides.

Major chemical classes of synthetic pesticides include: Carbamates, Organochlorines, Organophosphates, and Triazines. Newer classes include Pyrethroids and Neonicotinoids, synthesized to mimic nature's pest protection. Apart from synthetics, there are also the inorganic pesticides, which are natural minerals used as raw material inorganic compounds, botanic insecticide, microbial insecticides, insect growth regulators, and insect behavior regulators.

Pesticides are also sometimes described in terms of their modes of action. For example, *fumigants* are pesticides applied as gases to "sterilize" soil, while *systemics* work their way through a plant's tissue after being taken up at the root. In general, pesticides can be formulated as solution of water or oil; or emulsifiable concentrations. Often, specialized equipment is required for effective and optimized administration of pesticides.

HISTORY OF PESTICIDE USE

Humans have probably been dealing with pests for some 10,000 years. The first known pesticide was elemental sulfur dusting used in ancient Sumer about 4,500 years ago in ancient Mesopotamia. By the 15th century, toxic chemicals such as arsenic, mercury, and lead were being applied to crops to kill pests. In the 17th century, nicotine sulfate was extracted from tobacco leaves for use as an insecticide. The 19th century saw the introduction of two more natural pesticides, pyrethrum, which is derived from chrysanthemums, and rotenone, which is derived from the roots of tropical vegetables [Wikipedia 2016].

However, the "pesticide era" as we know it today, did not begin until the 1950s when infrastructure

and inventions developed for chemical warfare during the second world war were channelled to the production of pesticides and other agrochemicals. In the six decades that have followed, influenced largely by the newly-formed multinational agrochemical companies, age-long traditional farming practices such as crop rotation were replaced with extensive monocropping; and natural pesticides were supplanted by synthetic ones.

PESTICIDE MISUSE AND ABUSE

There is abundant evidence of poor pesticide education leading to extensive misuse in Nigeria [Ivbijaro 1990; Ivbijaro 1998; Asogwa and Dongo, 2009]. For instance, cases of over-dosage, for one reason or the other, have been reported as common. Even among government-trained, or agency-trained and assisted small-scale farmers, far more quantity of pesticides than prescribed is applied with the general expectation that it would effect more rapid killing of crop pests. Other unfortunate but common misuse of pesticides happening all around us include:

1) Pouring pesticides (particularly old stock of Gammalin – Lindane) into rivers to kill fish which is then sold for human consumption. Many have become poisoned as a result of such practices.
2) Spraying Gamalin 20 on drying cocoa beans to prevent moulds and maggot development.
3) Mixing of different classes of pesticides (eg fungicides and insecticides) together so as to reduce the workload of spraying each differently. Apart from affecting effectiveness, such a practice could also dramatically worsen the potential health hazards.[Asogwa and Dongo 2009].
4) Wrong use of nozzles for spraying equipment, making it difficult for desired quantity of pesticides to be administered. Both over-dispensing and under-dispensing could have significant adverse impacts on the environment and on human health.
5) Lack of knowledge on the time needed for degradation of pesticides
6) Use of wrong formulations and doses, and wrong timing of application (all borne out partly due to inability to properly distinguish one pest from the other)
7) Counterfeiting, faking, and recycling of old stocks, manufacturing of empty plastic containers to market adulterated agrochemicals, which are sold at reduced prices.
8). Careless disposal of expired pesticides into the environment as regular waste, due to lack of proper disposal facilities or protocols.

It has been difficult to obtain an estimate of pesticide use in Nigeria. As at June 2016, the Food and Agriculture Organization website which provides such information for several countries has no data for Nigeria [FAOSTAT, 2015]. However it has been estimated that by 1998, about 125,000-130,000 metric tons of pesticides were being applied every year in Nigeria. In 1991, cocoa pesticides accounted for about 31% of the total agro-chemical market of which fungicides accounted for 65% and insecticides 35% [Ikemefuna, 1998]. The two most-used pesticides in the world are the herbicides glyphosate (RoundUp) and atrazine [PANA, 2016].

HEALTH IMPACT OF PESTICIDES

Since pesticides are essentially poisons meant to kill or ward off unwanted living organisms, it is not surprising that they could produce adverse health impacts in people. Most affected are the people who directly apply the pesticides (such as farmers and applicators), followed by members of their immediate family, and ultimately, the general public who consume food products with high residues of pesticides. Children are the most vulnerable, partly due to biological factors as well as enhanced exposure factors [Zahm and Ward 1998, UNEP 2004].

It has been reported that, globally an estimated 1 million to 5 million cases of pesticide poisoning occur every year, resulting in 20,000 fatalities among agricultural workers. It is a sobering fact that although developing countries use only 25% of the world's production of pesticides, they experience 99% of the deaths [Jeyaratnam, 1990].

Factors for Aggravated Health Hazards from Pesticide Use in Nigeria

Some of the major factors leading to a preponderance of adverse health impacts associated with pesticide use in developing countries such as Nigeria, despite relatively lower volume used compared with developed countries, include the following:

1. The Deadliest Pesticides are used in Nigeria

It is the most-deadly chemicals that are used here due to their being cheaper than newer safer pesticides [McConnell and Hruska, 1993; Erhunmwunse *et al*, 2012]. The potential of a chemical released into the environment to cause harm is measured largely in terms of its toxicity and persistence.

Pesticides are classified by the World Health Organization, WHO, as extremely hazardous (Class Ia), highly hazardous (Class Ib), moderately hazardous (Class II), slightly hazardous (Class III) and unlikely to be hazardous under short-term use (Class U) [WHO 1990]. For some class Ia pesticides, just 5 ml taken into the mouth is sufficient to kill an adult human being. It has been well documented that small-scale farmers in developing countries use large amounts of pesticides belonging to classes Ia, Ib, and II due to these being cheaper than the less hazardous, newer ones [WHO 1990, McConnell and Hruska, 1993; Ecobichon, 2001; Konradsen *et al.,* 2003]. Invariably, newer safer formulations tend to be more expensive because they are protected by foreign patents, and local firms are not permitted to formulate them without paying heavy charges which eventually drive up market prices [McConnell and Hruska, 1993; Nnamonu and Onekutu, 2015].

Persistence defines the ability of a chemical to remain unchanged for long periods in the environment, during which time it is able to be transmitted through long distances via air, water and living creatures. Such chemicals could then be found copiously in areas where they were never used or produced. Furthermore, they store easily in fatty tissues and build up in food chains.[UNEP, 2004]. In 2001, under the auspices of the United Nations Environment Programme, nine highly-persistent pesticides (viz aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex, toxaphene, and hexachlorobenzene) were officially proscribed for use in agriculture. Unfortunately, several of these are still openly sold in Nigeria. Some are smuggled in or even donated by some "caring" donor countries [PAN, 2012]. Sometimes, the pesticides were donated while their use was still permitted, but a combination of excessive donation and poor logistics or timing results in delays in receiving the pesticides at the point of need, and they become "obsolete" while in stock [WHO, 1990; Baba, 2008]. People still go ahead and use them anyway. In India, where statistics are available, the Ministry of Agriculture has determined that one-third of the pesticide samples examined do not comply with official standards [PAN, 2012]

2. Poor legislation and Lack of Enforcement of Available Legislation.

In the first instance, all over the world, the scientific regulations pertaining to synthetic chemicals are suspected to be rather lax, and skewed more towards protecting the manufacturers' profit than the consumers' health. For instance, the toxicity classification was based on acute effects of single chemicals, a far cry from what can really happen when several chemicals are formulated together, and are ingested over long periods of time. Whereas, the civil and political agencies in developed countries show keen interests and appreciation of these lax scientific endorsements and therefore make appropriate legislations concerning use to provide further safeguards, the situation is different in Nigeria. In many cases, the required advisory on safe use of the products are in unreadable very fine prints, which many users simply ignore! Worse is the fact that even the basic regulations (largely advocated for by international watchgroups) governing the importation of banned or restricted pesticides into the country are largely unenforced [WHO, 1990; Nnamonu and Onekutu, 2015].

In Nigeria, the regulations governing use of chemicals are encapsulated in the ECOWAS Regulations on Pesticides which covers all activities involving experiments on, as well as authorization, marketing, use and control of

pesticides in the West Africa subregion; and the National Environmental (Hazardous Chemicals and Pesticides) Regulations, 2013 which deals with import, export, storage, usage, and marketing of hazardous chemicals and pesticides including other agrochemicals. The NAFDAC regularly issues permits, valid for five years, for specific brands of pesticide formulations that can be used in the country.

3. Issues With Correct, Effective, and Safe Applications of Pesticides

Too frequently, people get unnecessary serious exposure to pesticides while applying them. Mostly due to a combination of economic reasons and plain ignorance, many fail to put on required personal protective equipment such as gloves, overcoats, and masks [Asogwa and Dongo, 2009; PECAN 2013]. However, it has also been pointed out that it would have been extremely difficult for farmers "working in the tropical sun in a humid climate where ambient temperatures reach 40°C" to be wearing protective rubber gloves and respirators, even if they could afford them. [McConnell and Hruska, 1993]

In other circumstances, the time-tested safe protocols are found inapplicable in Nigeria for one reason or the other. For instance, in the cocoa business where a significant amount of pesticide use in Nigeria happens, best results are obtained when miricides are applied through fogging [Asogwa and Dongo, 2009]. The relatively small sizes of farms, together with presence of farm settlements and animals nearby however make this method inappropriate in Nigeria.

Contrasting working conditions typical of the developing world with those in the developed world, McConnell and Hruska [1993] observed that: "In the developed world, carbofuran granules are applied by tractor, entailing little exposure to the applicator. In Nicaragua, carbofuran was mixed with urea, which facilitated dermal absorption, and applied by hand. … In the developed world, acutely toxic liquid pesticides such as methamidophos are applied by planes or tractor-drawn boom sprayers. Among small farmers in the developing world, they are applied by backpack sprayers, and leakage is common."

It has been noted by researchers from CRIN that the Lancet spraying pumps despite its popularity among cocoa farmers in Nigeria, on account of relative low cost and ease of operation and maintenance, is not effective and not approved for use. Even then, the spraying equipment are generally neither calibrated nor well maintained. They are often leaking, thereby causing severe dermal and respiratory exposure [Asogwa and Dongo, 2009]. Ineffective application of pesticides leads to wastage of pesticides, and possible development of resistance by the target pests. These translate to economic losses and significant environmental problems.

4. Lack of Adequate Information, Knowledge, and Awareness of the Inherent Dangers of Pesticides.

The low level of information, knowledge, and awareness among Nigerians, on the dangers associated with the use of pesticides is simply alarming. For example, in a 2011 survey at the Dawanau International grain market, Kano State, responsible for a large percentage of cowpea consumed in Nigeria, over 80% of the traders interviewed averred that government's ban on the use of gammalin (lindane) to preserve beans against weevils is unjustified. Based on perceived effectiveness, lower costs, and non-persuasion about associated adverse effects, many of the merchants indicated they would continue to use the "time-tested" product [Adegbola, *et al.,* 2011].

5. Lack of Training on Correct Handling of Pesticides at Home

Even for those who understand that there are health hazards associated with the use of pesticides, several dangerous habits and practices have been innocently imbibed over the years. A major issue is the improper disposal of empty pesticide containers. Many people put empty containers to a variety of domestic uses including storage of water and powdered food following casual washing. Few people take time to thoroughly wash their hands with soap after the use of pesticides. In a similar vein, some use domestic utensils for measuring and dispensing pesticides while several others store pesticides in family bedrooms and unlocked cabinets that can easily be accessed by children [Asogwa and Dongo, 2009; UNEP, 2004]. A WHO report on

Iraq mentioned contamination of food with pesticides when transported together in the same vehicles [WHO, 1990].

6. Absence of Monitoring for Pesticide Residues on Locally-consumed Products, Unlike the Situation for Products for Export

Unlike cash crops or foods meant for export which pass through central facilities, such as NAFDAC, where the levels of pesticides residues are determined, foods consumed locally do not pass through such monitoring or evaluation. Unfortunately, there is no way an individual consumer can determine whether or not the vegetable or fruit or tuber he is consuming is laced with pesticides or not! Even more unfortunate is the reality that crops such as beans, sesame seed, pepper, etc that are rejected by foreign buyers on account of high level of residual pesticides are invariably returned to the country to be sold and consumed by unwary Nigerian public [Auwal-Ahmad and Awoyale, 2008; Abubakar, 2008].

7. Inadequacies in Medical Recognition and Responses to Pesticide Poisoning

The relative importance of adverse health effects attributable to pesticides ingestion should ordinarily have earned it a special place and attention during the training of healthcare personnel in Nigeria. As it were, medical personnel are not adequately trained to recognize and deal with pesticides poisoning, the symptoms of which can be easily attributed to other causes by an unsuspecting medical personnel [Konradsen F. *et al.* 2003, PAN 2012, Reigart, and Roberts, Barcelo and Hennion, 1997]. It has been pointed out however, that even in the United States of America, it is common for even astute physicians to misdiagnose pesticide poisoning, not just in mild cases but sometimes in serious poisoning cases. [NDRC 2016] The situation in Nigeria is not helped by the absence of any effective database on use of pesticides in the country, or of healthcare incidences related to their use. Analytical facilities for definite diagnosis are either too expensive or non-existent. Hence the difficulty of sensitizing medical personnel to such incidences.

Specific Health Impacts of Pesticides on People

Pesticides are designed to disrupt key biochemical processes associated with the nervous and reproductive systems of the target pests. In many cases these processes are similar among different organisms, whether pests or humans. For example, the organophosphate and carbamate insecticides poison insects by inhibiting the enzyme acetyl cholinesterase. This mode of action can also be toxic to people. Another pervasive mode of action of pesticides leading to adverse health impacts is via Endocrine disruption. In small doses these pesticides are able to mimic or block hormones or trigger inappropriate hormonal activity, while at high enough doses they may interfere with important developmental and reproductive functions leading to sterility, lowered sperm counts, cancer of the reproductive organs and other effects. [UNEP, 2004; WHO, 1990; PAN, 2012; McKinley R. *et al.,* 2008]

The severity of any effect from exposure to pesticide depend on the dose, the route of exposure, how easily the pesticide is absorbed, the type of effect of the pesticides and its metabolites, the accumulation and persistence in the body and lastly, the gender, age, and health status of the individual [WHO, 1990; Ojo *et al,* 2013].

The three major routes of human exposure to pesticides are skin, oral ingestion, and inhalation through the nose. The effect may be acute, showing immediately after the exposure, or chronic, showing only after prolonged use. Generally, insecticides are the most acutely toxic, while herbicides are the deadlier when considering chronic use.

Acute Poisoning

Acute poisoning can cause a range of symptoms in adults and children, depending on the type of pesticide. For example, commonly used organophosphorus and carbamate compounds have been documented as producing neurobehavioral effects, gastro-intestinal effects, and respiratory effects.

Neurobehavioral effects include fatigue, dizziness, tremors, poor concentration, panic attacks, and blurred vision. Nausea and vomiting are common manifestations of gastro-intestinal effects, while respiratory effects include dry throat and difficulty with breathing. Other symptoms of acute pesticide poisoning are effects involving skin and mucous membranes, such as stinging eyes, itchy skin, and a burning nose; and muscular symptoms, such as cramps, stiffness, and weakness. [McConnell and Hruska, 1993; Clarke *et al.*, 1997, Thiam, 2009; PAN, 2012; Wikipedia, 2016]. In some cases, acute pesticide poisoning can result in coma and death, either rapidly or over the course of weeks, depending on the characteristics of the product and type of exposure [UNEP, 2004].

Chronic Poisoning

While acute effects are quickly observed and could be swiftly contained and remedied, chronic effects are difficult to recognize. Hundreds of thousands of people could therefore have suffered irreparable damages before these insidious effects are noticed! Chronic effects of pesticide poisoning are mainly neurological, reproductive, developmental, carcinogenic, and immunological.

Neurobehavioral effects. Impaired development of the nervous system can cause lowered intelligence and behavioural abnormalities. [Grandjean and Landrigan, 2006] Pesticide exposure in the womb increases chances of developing autism or in delayed development. Recent results from a study in California, the state with the largest use of pesticides in the US, linked Organophosphates with the most severe cases of Autism Spectrum Disorder (ASD), Pyrethroids were linked to ASD immediately before conception and during the third trimester, and Carbamates were associated with developmental delay (DD) [Roehr 2014]. Studies from China have suggested that depression caused by pesticide use might be contributing to the incidents of suicides-by-pesticides in that country in addition to underlying socio-economic problems and the easy availability of highly toxic pesticides [Zhang. *et al.,* 2009, Beard, 2011].

It has been shown that exposure to certain pesticides increases by 600% the risk for the fatal neurological disease amyotrophic lateral sclerosis(ALS) where progressively, the brain becomes unable to control both conscious and unconscious muscle functions including movement, speech, eating and even breathing. Pesticides have similarly been established as significantly contributing to the risk of Parkinson's Disease [Firestone *et al.*, 2005, Hancock *et al.*, 2008].

Developmental and reproductive effects. Certain pesticides are believed to cause reproductive problems, such as spontaneous abortions, stillbirths, lower birth weights, birth defects and early neonatal deaths. For example, numerous studies have linked one of the most widely used weed-killers in Nigeria, Atrazine, with hormonal imbalances and sexual irregularities in frogs and fish, which result in, among other effects, males who produce eggs. In many cases, a relationship between PCBs and reduced sperm count and male sterility has been documented [Grandjean and Landrigan, 2006; Goldman, 1997].

Carcinogenic effects. Studies have revealed a correlation between pesticide use and sarcomas, multiple myelomas, cancer of the prostate, pancreas, lungs, ovaries, the breasts, testicles, liver, kidneys, and intestines as well as brain tumors. [Zahm and Ward, 1998; Alavanja *et al.,* 2004, ChemTrust, 2010].

Immunological effects. A weakened immune system, particularly in growing children, exacerbates the risk of infectious disease and cancer, thus increasing mortality rates. This would be especially menacing in developing countries, where children face greater exposures to infectious agents [Repetto and Baliga, 1996].

In addition to the above main effects, pesticides can also promote autoimmune disease (e.g. diabetes, lupus, rheumatoid arthritis, asthma), as well as allergy sensitization reactions. A recent study suggests that pesticide exposure can cause disease across three generations [Devon, 2016].

OTHER PROBLEMS AND ISSUES WITH PESTICIDES

Apart from the adverse health impacts on people (caused by exposure to pesticides during applications or as residues in food) there are several other serious issues with uncritical use of pesticides. As established by several investigators, typically only about 15% of applied pesticides directly hits the target pests and pathogens. The remaining 85% is thereafter distributed in soils and air [Victor *et al.*, 2015]. According to Erhunmwunse *et al.* [2012], over 98% of sprayed insecticides and 95% herbicides reach a destination other than their target species, including non-target species, air, water and soil. In soils, pesticides residue can move from the surface when they dissolved in runoff water, or percolate down through the soil, and eventually reach the groundwater.

Some of the major problems arising from these pesticides in the environment include the following:

Disruption of Ecological Balance and Collapse of Biodiversity:

In the 1960s, it was discovered that DDT was preventing many fish-eating birds from reproducing, thus constituting a serious threat to biodiversity. As a result of indiscriminate use of pesticides (particularly the synthetic ones), bees, bats, amphibians and other beneficial species are dying off in droves. Such disruption of the ecological balance of agricultural areas via killing off of natural biological controls, invariably leads to outbreaks of pests that were previously of minor importance (secondary pests), leading to new problems and an unending dependence on more and more pesticides. And the cycle repeats itself unsustainably.

Biologists have generally advocated that mankind ought to pay at least equal attention to biodiversity loss as it does to climate change.[PANA, 2016]

Unsustainable Chemical reliance

Often, the massive disruption of the complex biological ecosystem of the soil requires other chemical inputs, notably fertilizers, to obtain pre-pesticide levels. This supplanting of biological controls with synthetic chemicals (so-called chemical reliance) has been shown to be unsustainable. As aptly described by the Pesticide Action Network (PAN): "This model of farming is inefficient and does not represent the cutting edge of modern farming…Following this path we have become dependent on cheap, abundant oil, and on quick chemical "fixes" for agro-ecosystem challenges that are complicated and require deep, local and hands-on knowledge. In relying on chemical inputs, we have un-learned how to farm."[PANA, 2016a; PANA, 2016b; Victor *et al.*, 2015].

Pesticide Resistance

Just as in the highly celebrated case for antibiotics resistance, pests also develop resistance to pesticides with time. It is now estimated that there are more than 500 insect pest and mite species that have shown resistance to the regular pesticides designed for them. This invariably leads to what is referred to as the "pesticide trap," where farmers are forced to use more and more and increasingly toxic chemicals to control insects and weeds that develop resistance to pesticides. As pointed out by the PAN, "As "superbugs" and "superweeds" develop in response to widespread and continuous use of chemicals, a farmer will spend more on pesticides each year just to keep crop losses at a standard rate"[PANA, 2016b] It is ironic that manufacturers of pesticides are using the problem so generated to promote genetically-modified crops. Currently, Monsanto is trying to introduce to Nigeria, so-called glyphosate-ready crops which could tolerate the use of the herbicide glyphosate, also produced by Monsato. Meanwhile, glyphosate has now been declared by the WHO as most likely capable of causing cancer.

Economic issues

The combination of secondary pest outbreaks, insect resistance, government regulations, and legal battles over safety and the environment, invariably have implications for the economics of conventional pesticide use. Often there are other hidden costs such as a high demand for fresh water use (apart from polluting the rest water resources) associated with high demands for pesticides. In several parts of the world, notably India and China, debt-ridden farmers are committing suicides – mostly by ingesting the very pesticides that have brought them so much misery.

SUGGESTED ACTION POINTS

Government should institute measures to consciously liberate our food industry from the unprofitable and unsustainable high dependence on chemicals, as we now face. This has to be implemented in phases, via the popularization and enlargement of the commendable Integrated Pest Management (IPM) scheme.

Furthermore, government should ensure that mechanisms are put in place to effectively ensure that all banned chemicals are not brought into the country. Those already in the country, and on display with complete impunity in our markets, should be removed and disposed of correctly. Related to this, tested protocols for safe disposal of expired, obsolete or otherwise unwanted pesticides should be put in place and well publicized. Government through its various relevant agencies should ensure constant availability in the markets of those active ingredients that are within the new class of allowed pesticides at reasonable costs.

Relevant research and healthcare institutions should be encouraged and empowered to keep a database on pesticide use and incidents of pesticide poisonings in Nigeria. This will help in developing appropriate responses in a timely manner to reduce the adverse impacts associated with pesticide use in the country.

Finally, Government should consider promoting gamma irradiation of foodstuffs for increasing the shelf life of foods and thereby reducing the need for chemical preservation [IAEA, 2003]. The food irradiation programme at SHETCO Abuja should be revived and replicated at other centres in the country.

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