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Review

Beyond pest control: A closer look at the health implication of pesticides usage

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Medical advances through various centuries had previously centered around the prevention and control of communicable diseases. Various curative and preventive strategies were developed to combat diseases considered to be of public health importance. While the desired results have been achieved and the effects enjoyable, with the effective control of pests as well as other agents that affect man's wellbeing, some untoward consequences have been noted. Pesticides have been used for several years, but little attention was initially paid to the toxicology of these substances. This paper discusses the health effects of pesticides on humans, advocates for increased surveillance, safer products and protection of the vulnerable public. The various agencies involved in the control of pesticides usage, manufacture and distribution need to be more pro-active in the execution of their duties. Intersectoral collaboration, among public health, education and agricultural workers, is essential to having a healthy population and environment.

Key words: Pesticides, food, public health, diseases.

INTRODUCTION

There has been increasing concern about the effects of environmental exposure to toxins on people in high risk areas. This necessitated research into various toxicological effects of chemicals and other physical substances used in industries and the living environment.

More recently, some level of awareness has been raised on the untoward effect of household exposure to chemicals used for domestic purposes. An example of such chemicals, which are used both at commercial and household levels, are the pesticides.

The word "pesticide" is a composite term including any substance or mixture of substances, intended for preventing, destroying, repelling or mitigating any pest (Reigert et al., 1999). It may be a chemical substance, biological agent (such as a virus or bacterium), antimicrobial, disinfectant or device used against any pest. The food and agricultural organization, FAO, perhaps, defined the term 'pesticide' in the most explicit manner as: any substance or mixture of substances intended for preventing, destroyed or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feed stuffs, or substances which may be administered to animals for the control of insects, arachnids or other pets in or on their bodies. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant or agent for thinning fruit or preventing the premature fall of fruits, and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport (FAO, 1992). Pests include insects, plant pathogens, weeds, molluscs, birds, mammals, fish, nematodes (roundworms) and microbes that destroy property, spread disease or cause a nuisance.

Before 2000BC, humans started utilizing pesticide to protect their crops. The first known pesticide, elemental

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sulphur dusting, was used in ancient summer about 4,500 years ago in ancient Mesopotamia. By the 15th century, toxic chemicals such as arsenic, mercury and lead, were being used as pesticides.

These were followed closely by nicotine sulphate, extracted from tobacco leaves, for use as an insecticide. The 19th century saw the introduction of two more natural pesticides, pyrethrum (derived from chrysanthemums) and rotenone (derived from the roots of tropical vegetables). A few people consider the 1940s and 1950s to have been the pesticide era. Until the 1950s, arseric-based pesticides were dominant. Herbicides became common in the 1960s, led by triazine and other nitrogen-based compounds, carboxylic acids, such as 2,4-dichloro phenoxyacetic acid and glyphosate.

Pesticide use has increased 50-fold since 1950 and 2.3million tonnes of industrial pesticides are now used each year (Stephenson et al., 1993). Pesticides are used in grocery stores and food storage facilities to manage rodents and insects that infest food such as grains. Pesticides save farmers money by preventing crop losses to insects and other pests. It is estimated that about a four-fold return on money spent on pesticides, is made by farmers regularly.

Although there are benefits to the use of pesticides, there are also drawbacks, such as potential toxicity in humans and other animals. Pesticide use raises a number of environmental concerns. Much of the sprayed insecticides and herbicides reach destinations other than their target species, including air, water and soil, thereby affecting the balance in the ecosystem. WHO and UN Environmental Programme (UNEP) estimate that each year, 3million workers in agriculture in the developing world, experience severe poisoning from pesticides, about 18,000 of whom die. Pesticides have been linked with various forms of adverse health consequences (WHO/UNEP, 1989). This paper discusses the use of pesticides, their health implications and strategies to prevent the unwanted effects, associated with them.

NATURE OF PESTICIDES

Pesticides are a heterogeneous group of compounds and mixtures. They can therefore be classified in various ways, and expectedly, have various mechanisms by which they exert their effects. Pesticides control pests by physically, chemically or biologically interfering with their metabolism or normal behaviour. Pesticides are used in grocery stores and food storage facilities to manage rodents and insects that infest food such as grains. Pesticides save farmers money by preventing crop losses to insects and other pests. It is estimated that about a four-fold return on money spent on pesticides, is made by farmers regularly.

Most pesticides are lethal to target pests when applied at the rate specified on the label. Some are non-lethal to the target pest, including repellents or attractants (such as personal insect repellents), sterilizing agents (which interfere with the reproductive ability of a pest), some defoliants (which cause leaf drop without killing the plant) and some pesticide products that boost the action of another pesticide without being particularly toxic themselves. The route that brings a pesticide in contact with the target pest depends on the nature of the pesticide, how it is applied and the type of environment in which the pesticide is placed. Common application methods include: spraying, fumigating and baiting.

Most pesticides are contact pesticides. They need to be absorbed through the external body surface or exposed plant tissue, to be effective other pesticides are systemic in action. Systemic pesticides can be transported from one site to another within the plant or animal, where they become effective. This is clearly illustrated with the use of insecticides, absorbed by foliage and translocated throughout the plant, where they kill chewing or sucking insects; or nematicides that are applied to the leaves of plants and are transformed to the roots of the plant to kill worms or caterpillars that are attacking the plant's roots.

Similarly, blood anticoagulant rodenticides in baits take effect once they have been transferred from the digestive system to the bloodstream of rats. Insecticides are probably the most common type of pesticides used as insects are arguably the most destructive globally. Insecticides destroy, suppress, inhibit the feeding of, or prevent infestations or attacks by an insect.

Agricultural crops can be genetically modified to make them more resistant to pests and diseases, or tolerant to certain herbicides. Where a genetically-modified product is designed to be a pesticides, it is subject to an assessment and registration process. Some chemicals, known as "Lures" are used to attract pests to pesticides. Pesticides can be classified in various ways, some of which includes:

By target organism
By chemical structure/families
Classification as organic/natural) inorganic/synthetic or biological (biopesticides) and
By biological mechanism/functions.

Classification by target organism includes:

Algaecides (for control of algae)
Avicides (for bird control)
Bactericides (for control of bacteria)
Fungicides (for control of fungi and oomycetes)
Herbicides (e.g. glyphosate), for weed control.
Insecticides (e.g. organochlorines, organophosphates, carbamates and pyrethroids) for the control of insects – these can be ovicides (substances that kill eggs), larvicides (substances that kill larvae) or adulticides (substances that kill adults).
Miticides or acaricides (for the control of mites).

Molluscicides (for the control of slugs and snails).
Nematicides (for the control of nematodes).
Rodenticides (for the control of rodents) and
Virucides (for the control of viruses).

Pesticides can also be grouped into chemical families. Prominent insecticide families include organochlorines, organophosphates, and carbamates. Organochlorine/chlorinated hydrocarbons can be sub grouped into dichlorodiphenyl ethanes, cyclodiene compounds, and other related compounds. They operate by disrupting the sodium/potassium balance of the nerve fibre, forcing the nerve to transmit continuously. Their toxicities vary greatly, but they have been phased out because of their persistence and potential to bio-accumulate.

Organphosphate and carbamates have largely replaced organochlorines. The initial products of organophosphate insecticides were highly toxic to mammals (parathion, dichlorvos), but safer varieties have been produced. Carbamates are less toxic to vertebrates than organophosphates and have somewhat replaced them. Prominent herbicide families include: phenoxy and benzoic acid derivatures (e.g. 2,4-D); triazines (.e.g. atrazine); ureas (e.g. diuron); and chloroactanilides (e.g. alachlor). Many commonly used pesticides are not included in these families, including glyphosate. Classification of pesticides as organic/natural, inorganic/synthetic or botanicals could be quite blurred. The plant derived pesticides or “botanicals”, have been developed at a fast pace. The most widely used are pyrethroids. Others include ryania, rotenoids, nicotinoids and a group containing strychnine and sciliroside. Synthetic pyrethroids also exist and are in use for their residual activity especially in impregnated nets. Many other natural substances can be used as pesticides, such as extracts of pyrethrum, garlic, tea-tree oil and eucalyptus oil (Hayes et al., 1991).

Degradation of pesticides

How quickly a pesticide breaks down depends on its chemical properties, the quantity applied, its distribution, as well as environmental factors, such as temperature, moisture, soil pH and the availability of micro-organisms. In addition to chemical and photochemical reactions, two principal biological mechanisms cause degradation of pesticides. These are:

Microbiological processes in soil and water

Metabolism of pesticides in soil is by the process of mineralization and results in the conversion of the pesticides into simpler compounds such as water, carbon (IV) oxide and ammonia. The process is a combination of chemical reactions, such as hydrolysis and photolysis. As well as microbial catabolism and metabolism. The soil biota utilizes the pesticide as a source of carbon on other nutrients (Kah et al., 2007).

Pesticides residue

A very small amount of a pesticides or its metabolite (or degradation product), can remain in a crop until it is harvested, following treatment. This is known as the residue. It is well documented to be present in fresh or tinned fruits and vegetables, processed food and drink, made from crops (particularly juices, bread or other foods and drinks) as well as in fresh or processed animal products (if the animals have been fed on crops, treated with pesticides). The amounts or levels of residues present are expressed in milligrams (of the chemical) present in a kilogram or crop/food/commodity (mg/kg) (Atkin et al., 2000; John et al., 1990). Due to the formation of residues, some pesticides are persistent in action and continue to be effective for days, weeks or months after their application (Minyard et al., 1991). Many modern pesticides do not persist for long in the environment. They are quickly degraded to non-toxic substances by environmental or microbial processes.

Exposure to pesticides

Many avenues of exposure to pesticides exist. Extensive use of synthetic pesticides for agricultural, industrial, public health and domestic purposes has been on for several years. As a result of their widespread use, exposure to hazardous pesticides is a concern to the general population and occupationally exposure persons. In general, there are three principal sources of human exposure to pesticides, which are:

Occupational (including agricultural): Non-occupational (occurs with non-commercial treatments of dwellings and workplaces, home gardening etc) and dietary (that is, an indirect exposure of the population through the use of pesticides on agricultural commodities). The major types of occupational exposures, in terms of the magnitude and frequency of exposure, are agricultural (mixers, applicators and harvesters), professional pesticides applicators who treat dwellings and workplaces and workers in pesticide manufacturing plants (Kishi, 2002). The dietary route is the most significant route of exposure in terms of the number of people potentially exposed, even though the magnitude of such exposure is generally lower than that resulting from occupational or household use of pesticides (John et al., 1990). Virtually everyone receive at least occasional doses of pesticides via the diet and water, both for drinking and domestic use.

Health implications: Pesticides can be dangerous to

consumers, workers and close bystanders during manufacturer, transport, or during and after use. For pesticides to be effective against the pests they are intended to control, they must be biologically active or toxic. Due to these properties, they are potentially hazardous to humans, animals and the environment. Pesticides toxicity and exposure hazard is the potential for injury, or the degree of danger involved in using of pesticides under a given set of conditions.

The harmful effects that occur from a single exposure by any route of entry are termed “acute effects or acute toxicity”. Any harmful effects that occur from small doses, repeated over a period of time are termed “chronic effects or toxicity”. These effects are multi-systemic (Maroni and Fait, 1993). Routes of exposure to pesticides (that is, the means by which they get into the human body) include: the dermal (skin) route, inhalation (lungs); oral ingestion and the eyes. Delayed responses to pesticide exposure are well documented (Brahim et al., 1998). The adverse health consequences of pesticides are more pronounced in children than in adults. Health effects associated with pesticides use range from allergic dermal conditions to neurological and congenital anomalies specific dermatitis an skin reactions present with symptoms including swelling, redness, priorities, pain and blusters (Sanborn et al., 2007; Jurewuiz et al., 2008; Landrigan et al., 1999; Arbuckle et al., 1998).

The commonly used pesticides, chlorpyrifos (brand name, Dursban) caused severe birth defects in four children exposed in-utero. The study noted varying types of birth defects including absence of limbs, eyes etc (Sherman, 1996). Several studies have found higher rates of birth defects in children born to pesticides applicators, farmers and people residing in regions where herbicides and fungicides are widely used. Defects noted were limb deformities, cleft palates, hypospadias and testicular malformation (Wikkinson et al., 1995; Lu, 2005).

Babies living near wheat-growing agricultural areas were found to have a greater risk (about 65%) of having circulatory and respiratory defects, as a result of the use of chemical pesticides, particularly the chlorophenory herbicides, containing 2, 4-D. A hundred percent rise in respiratory and circulatory defects was noted, if heart malformations were excluded (Schreinemachers, 2003). Another insightful study provides evidence, suggestive of harm to child brain development during pregnancy following exposure to chlorpyrifos (dursban)(Whitney et al., 1995). Pesticide exposure has also been found to cause miscarriages (Bell et al., 2001b). Fetal deaths have been associated with living close to agricultural pesticides use during weeks 3-8 of pregnancy. The results of the study showed an approximately two-fold greater risk of having stillbirth if the mother lived within 1 mile from an agricultural area which used organophosphate pyrethroid, carbamate or chlorinated pesticides. Primary defects contributing to the death of the children were urinary and multiple congenital anomalies (Bell et al., 2001a).

Neurologic disorders and pathology have been linked to pesticides use. Pesticides can be potent neurotoxins. When people are exposed to neurotoxins, they may feel dizzy, lightheaded, confused and may have reduced co-ordination and ability to think as well as depression, manifested as short-term effects (Joy, 1993).

In adults, pesticides have been found associated with Parkinson’s disease. In individuals with a genetic predisposition, exposure to permethrin may trigger chemical events in the brain that result in an increased risk for damage to the area of the brain that is selectively damaged in Parkinson’s disease. Agricultural areas have been reported to have higher incidents of mortality from Parkinson’s disease (Ritz et al., 2000). Polyneuropathy has been specifically linked to organophosphates (Lotti, 1992). Various malignant tumors have been associated with pesticide exposure. Phenoxyherbicides, particularly 2, 4-D (94757) have been linked with increased risk of non-hodgkin’s lymphoma. Persons with occupations closely related to pesticide use, particularly farmers, applicators of pesticides, grain millers, wood and forestry workers, chemists, petroleum industry workers, have been reported to be at increased risk of non-Hodgkin’s lymphoma (Pressinger et al., 1994). Several studies have concluded that certain childhood tumors are linked to pesticide exposure including leukemia, wilm’s tumor and soft tissue sarcoma. Indoor pesticides have been specifically associated with increased cancer incidence children (Buckley et al., 2000). Homes treatment with pesticides has been linked to development of Neuroblastoma (Daniels et al., 2001). Cancers in adults associated with the use of pesticides include ovarian cancer, prostate cancer, lung cancer and skin cancer (Bassil et al., 2007). Cassidy et al conducted a research in Texas and found that cancerous breast tissue contained the chemical, heptachlor epoxide. This is a chemical found in the common home pesticides, chlordane. It was at levels four times higher than in non-cancerous breast tissue (Cassidy et al., 2005).

Exposure to some fungicides and insecticides may increase the risk of retinal degeneration and blindness. Pesticides still in use, including 2-4,D lindane and atrazine, are known endocrine-disruptors. Endometriosis, hypospadias and undescended testes, have also been identified as consequences of pesticides exposure.

Control measures

Pesticides can be double-edged swords, as discussed earlier in this paper. While they are desirable for their positive (enhancing) effects, the negative environmental and health consequences require calling for a great deal of caution in their usage.

Before using any pesticides, the label should be checked and necessary information confirmed. The hazard symbol, trade name of the product, name and

quantity of active ingredient, purpose for which it is used as well as the registration number (when required by legislation) should be noted. The following should also be considered: name and address of the manufacturer, distributor or agent; directions for use; safety precautions, warning and statements of good practice, first aid instructions and advice to health personnel, name and quantity of any solvent or similar material classified as hazardous, identification number of the batch or consignment, interval between agrochemical application and harvesting.

It is important to choose a pesticide with the least toxicity, as much as possible. Products need to be kept in their original containers and away from pets and children. There must be a conscious effort to avoid absorption by ingestion, particularly for agricultural workers. Farmers need to be educated on the need to avoid eating, drinking or smoking during pesticides applications. Spraying of pesticides should be done only when the weather conditions are suitable. Personal protective equipment must be utilized in order to minimize risks to the handlers. Alternatives to pesticides are available and include methods of cultivation, use of biological pest controls (such as pheromones and microbial pesticides), genetic engineering, and methods of interfering with insect breeding. Application of composted yard waste has also been used as a way of controlling pests. These methods have become popular and are often safer than traditional chemical pesticides (Pimental, 1996). Poly culture (growing multiple types of plants), crop rotation, planting crops in areas where the pests that damage them do not live, timing planting according to when pests will be least problematic, and use of trap crops that attract pests away from the real crop are measures that have proven useful. Recently, a new approach being introduced in the use of pesticides in Nigeria is the integrated pest management, with the main objective being to reduce reliance on synthetic pesticides and enhance biosystems that allow a balance between beneficial fauna, flora and pests. This concept requires safer, more directed and less wasteful technique for the application of pesticides or other pest control agents (Kegan, 1998). Practical use of spatial analysis for pest management is being advocated (Brenner et al., 1998).

Monitoring of exposure to pesticides is an effective control measure. Exposure assessment could be through measurement of environmental concentrations or measurement of the metabolites of the pesticides in human tissues. The concentration of metabolites could be assessed in blood (serum and plasma), urine, saliva, sweat, amniotic fluid and meconium. Many highly sensitive and specific methods have been developed with the ability to measure general population exposures with great precision.

Monitoring for pesticides residues in food is the most desirable method of generating data, for estimating dietary exposures (Wales et al., 1994; Viana et al., 1996; Blesa et al., 2003; Valenzuela et al., 1999; Zhang et al., 2005; Lehotay et al., 2000; Obana et al., 2003). However, this is expensive, time-consuming and requires a great deal of political will, which is often lacking in developing countries, like Nigeria.

In Nigeria, a number of problems exist with regards to safety of pesticides application and related issues. Huge amounts of pesticides are wasted or unnecessarily applied, putting a number of persons involved at risk of intoxication. This is mainly because the principles of application technology are not known. Often times, the equipment used are obsolete and working conditions poor. Regulation of the chemicals used as pesticides is week coupled with the absence of a toxicological center for reporting hazards or accidental contamination.

CONCLUSION

Pesticides have left many with bitter sweet memories, depending on the individual's experiences with their use. While it does reduce the toll of pests on the economy, its adverse effects cannot be overlooked. Adequate adherence to standard precautionary measures will safeguard the health of the general public. The ministries of health, environment, agriculture and education should work together to educate, prevent undue exposure and treat affected persons due to pesticides exposure. All regulatory bodies must live to their responsibilities. That is when our safety is assured.

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