Greener Journal of Environmental Management and Public Safety

ISSN: 2354-2276

Health Implication of Excessive Use and Abuse of Pesticides by the Rural Dwellers in Developing Countries: The Need for Awareness

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Review Article

Health Implication of Excessive Use and Abuse of Pesticides by the Rural Dwellers in Developing Countries: The Need for Awareness

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ABSTRACT

Pesticides are chemicals essentially needed for food security and health purpose, adding that most of the time, they are being wrongly applied and abused especially by the rural dwellers in developing countries such as Nigeria. The health implication of abuse and misuse of pesticides were reviewed and ways forward suggested. This review will provide the benefits of pesticide use, awareness of the risks posed to people, wildlife and ecosystems. The paper looks into how manufacturers, users and government can minimize risks posed by pesticides. Manufacturers and users should be held more accountable for reducing both short and long-term risks of pesticide use. The primary obligation of manufacturers is to minimize risks posed by pesticides. To ensure that adverse effects on human health and the environment are prevented, pesticide registration, product labeling, government enforcement and applicator education should form the foundation of a comprehensive framework to regulate the manufacture, use and disposal of pesticides. If the various mitigation processes suggested in this review is adhered to, the developing countries will be less contaminated with environmental hazards.

Keywords: Pesticides, health, rural dwellers, developing countries, risks.

INTRODUCTION

It is now obvious that the physical, chemical with the biological integrity of our planet is being compromised daily. The destructive processes are increasing both in quantum and in rate. The impacts have resulted in loss of biodiversity and destruction of natural habitat. In developing countries, both nature and man are at work endangering the environment and our health even as we presently lack the knowledge, technology, human capacity, financial resources and the political will to remediate it (Halidu, 2009).

The term pesticide depicts any of a wide range of environmental interventions with the objective of reducing to suitable levels of insect pests, weed population and plant pathogens. Most common pesticides include insecticides, fungicides, herbicides, rodenticides, nematicides, et cetera. Among the most effective are the chlorinated hydrocarbons. They are used in controlling a number of diseases, such as malaria, typhus and weed control. Pesticides have been an environmental threat, and why this threat is diminishing in developed countries, it remains a problem in many developing countries (Tovignan et al., 2001). The developed countries have banned many of the older pesticides due to potential toxic effects to man and/or their impacts on ecosystems, in favour of more modern pesticide formulations. Developing countries maintain that they cannot afford, for reasons of cost and/or efficacy, to ban certain older pesticides. The dilemma of cost/efficacy versus ecological impacts, including long range impacts via atmospheric transport and access to modern pesticide formulations at low cost remains a contentious global issue.

Herbicides are used far more than other types of pesticides and they became so popular that many farmers and gardeners depend solely on it for controlling weeds. Herbicides sometimes contain ingredients that are poisonous to humans and other organisms. Atrazine, for example, the most widely used agricultural herbicide, promotes the imbalance of estrogen, which has been linked to breast cancer (Kettles et al., 1997). Herbicides in the soil can migrate to the ocean through nearby streams or rivers and some, in minute concentrations, kill shellfish. Repeated herbicide use over a long period of time also encourages development of herbicide-resistant weeds (Kettles et al., 1997).

The concentration of pesticides have been detected in almost all segments of environment and food due to their extensive use and abuse.They have shown potential to biomagnify/accumulate in animal tissue, human blood, adipose tissue and breast milk (Metcaf, 1997). There is currently widespread concern about the concentrations and effects of pesticides on aquatic resources in the western Niger Delta, Nigeria. Ezemonye et al., 2010 recorded concentrations of organochlorine, organophosphate and carbamates in Warri River, Niger Delta, Nigeria. In addition, a good number of studies have been done in which organochlorine (OC) pesticide residues have been detected in fish samples from Lagos Lagoon, Nigeria (Adeyemi et al., 2008). In 2011, studies carried out in the Borno state, Nigeria revealed the presence of Lindane, Diazinon and Aldrin in the pre storage bean samples, while DDT, Dichlorvos and Endrin were present in both pre storage and in post storage samples (Ogah, 2011). Similarly, National dailies reported 120 students of Government Girls Secondary School, Doma in Gombe, Nigeria were rushed to the Gombe Specialist Hospital after consuming a meal of beans that was suspected to have been preserved with poisonous chemicals - 10 of these students were reported to be in critical condition. The result of the analysis showed that samples of the cooked beans and the uncooked beans contained outrageously high levels of lindane, an organchlorinated pesticide that was banned under the 1989 Rotterdam convention (Awofadeji, 2008).

Accidental contaminations which are very prominent in developing countries could be very serious and even fatal. For instance, in 1958, all members of the family of a local chief who is a prominent cocoa farmer at Okebode in southwestern Nigeria were hospitalized after eating a leaf vegetable undergrowth of a cocoa farm that was earlier sprayed with lindane. In 2004, carbofuran pesticide residues found on several batches of noodles manufactured in Nigeria may have resulted in 23 reported cases of vomiting and one death (Oluromíniyi and Emily, 2011). In August 2011, six family members died in Gombi Local Government Area of Adamawa State, Nigeria after eating moin moin prepared from suspected poisoned beans. The same year, many citizens of Bekwarra Local Government Area of Cross River State found themselves in the hospital after eating moin moin and beans. Two children were even said to have died from the incident. Also, in June, 2012 people reportedly suffered from pesticides poisoning at Yassharu village in Kafur Local Government Area of Katsina State after eating maize preserved with pesticides. More than 400 people reportedly died in Iraq in 1972 after eating bread that had been prepared from cereals treated with a fungicide (Oluromíniyi and Emily, 2011). Also, at least 37 people reportedly died of endosulfan in Republic of Benin during the 1999/2000 cotton growing season (Oluromíniyi and Emily, 2011).

Though Pesticides are beneficial, inappropriate use can be counterproductive and threaten the long-term survival of major ecosystems by disruption of predator-prey relationships, loss of biodiversity, increase pest resistance and kill the natural enemies of pests and can have significant human health consequences (Hori et al., 2008) and hence should essentially be subject to safe and judicious use. In spite of the upsurge in the use of pesticides in developing countries, there has been little or no awareness among the users of the hazard to the environment. Many users are inadequately informed about potential short and long-term risks, and the necessary precautions in the correct application of such toxic chemicals are not always made (Damalas et al., 2011). Information on their use, distribution and environmental impacts is scanty in Nigeria. The most recent guideline in Nigeria by the Federal Environmental Protection Agency is (FEPA, 1991) is about two decades old and urgently need updating. The hazardous nature of pesticides and their inherent toxicity and ability to cause poisoning “makes it mandatory that we ensure the safety of the user, our populace and the environment (Akunyili, 2008). Importantly, agricultural extension workers, farmers, grain merchants and other stakeholders “get acquainted with the correct application of registered agrochemicals for use and ensure that all safety measures are strictly adhered to during application. Research objectives was to inform the users of pesticides in developing countries of the effects of its misuse, especially problems experienced by smallholders, their families, food consumers and rural communities and the environmental effects.

BENEFITS OF PESTICIDES

Enhance Production

Pesticides have been an integral part of the process by reducing losses from the weeds, diseases and insect pests that can markedly reduce the amount of harvestable produce. Webster *et al*., (1999) stated that “considerable economic losses” would be suffered without pesticide use and quantified the significant increases in yield and economic margin that result from pesticide use.

Improve Food Quality

It has been reported that a diet containing fresh fruit and vegetables far outweigh potential risks from eating very low residues of pesticides in crops (Brown, 2004).

Control of Diseases and Wood protection

Pesticides are very essential in amelioration of vector-borne diseases. Insecticide is used extensively to control the insects that spread diseases such as malaria. Malaria is one of the leading causes of morbidity and mortality in the developing world (Ross, 2005). Insecticides are used extensively to protect buildings and preserve wooden structures from damage by termites and other wood boring insects.

MISUSE AND ABUSE OF PESTICIDES

The misuse or unsafe use of agricultural pesticides is not limited to developing countries. Toxic agricultural pesticides that are meant for outdoor uses are often used indoors even in developed and industrialized nations for the control of household pests. An extensive indoor application of methyl parathion, a restricted-use agricultural pesticide, led to the temporary relocation of more than 250 households in Jackson County, Mississippi, U. S. in 1997 (Oluro miniyi and Emily, 2011). Some of the factors responsible for dangerous use of pesticides that are especially common in developing countries include;

i. poor reading habit of the literate farmers/user or illiteracy of the rural farmers, therefore inability to read and follow label instructions and guidelines
ii. no stringent regulations and the lack of enforcement of existing ones, and the importation of toxic agricultural pesticides that have been banned or whose use are severely restricted in developed and industrialized countries
iii. the use of leaking equipment
iv. the use of domestic utensils for measuring and dispensing pesticides
v. exposure to pesticide drifts, failure to wear personal protective equipment (PPE) such as gloves, long pants and respirators
vi. inflexible, scheduled application of pesticides irrespective of the level of pest infestation “calendar spraying”
vii. storage of pesticides in family bedrooms and in unlocked cabinets that can easily be accessed by children
viii. improper disposal of empty pesticide containers
ix. the use of empty containers for domestic purposes – e.g., storing foodstuff and water for both humans and domestic animals.

Impacts of Pesticides

No segment of the population is completely protected against exposure to pesticides and the potentially serious health effects, though a disproportionate burden is shouldered by the people of developing countries and by high risk groups in each country (WHO, 2006). The deaths and chronic diseases due to pesticide poisoning is about 1 million per year (WHO, 2006).

Effects of Pesticides on Environment

When pesticides are exposed, there is tendency of causing havoc to the environment. Most of the pesticides reach a destination other than their target. Pesticide contaminates land and water when it escapes from production sites and storage tanks, when it runs off from fields, when it is discarded, when it is sprayed aerially and when it is sprayed into water to kill unwanted plants (Tashkent, 1998). If peradventure, pesticides enter aquatic environment, there are dangers to fish, birds, wild animals and plants in that habitat. The original molecule often is modified as it enters and interacts with the environment. Pesticides often are degraded in water (hydrolysis), by sunlight (photo degradation), and by soil and aquatic microorganisms (microbial degradation). Knowledge of transformation rates and the products and toxicity of transformation is the key to assessing ecological risk.Application rates and techniques have direct bearing on how a pesticide enters the environment. A pesticide applied at a rate of *ounces or less* per acre has a lower potential for exposing fish and wildlife than the same chemical applied at a rate of *pounds* per acre. In addition, persistent pesticides such as DDT pesticide may bioaccumulate, move through the food chain and eventually be ingested by and adversely affect birds, wild animals and domestic livestock. Methyl bromide which is currently being replaced by phosphine for the fumigation of stored cocoa beans has been identified as an ozone-depleting substance (Oluro miniyi and Emily, 2011).

Attenuation of Soil Fertility

The use of pesticides has impacted negatively on the soil organisms that are similar to human extensive and misuse of antibiotics. The use of pesticides might work for a while, but after some times, the soil organisms that has been carried out aeration and decomposition of organic matters dies, and therefore, there may not be or no beneficial soil organisms to hold onto the nutrients". For example, plants depend on a variety of soil microorganisms to transform atmospheric nitrogen into nitrates, which plants can use. Common landscape herbicides disrupt this process: triclopyr inhibits soil bacteria that transform ammonia into nitrite (Pell *et al*., 1998); glyphosate reduces the growth and activity of free-living nitrogen-fixing bacteria in soil (Santos and Flores, 1995) and 2,4-D reduces nitrogen fixation by the bacteria that live on the roots of bean plants (Fabra et al., 1997), reduces the growth and activity of nitrogen-fixing blue-green algae (Tözüm-Çalgan and Sivaci-Güner, 1993), and inhibits the transformation of ammonia into nitrates by soil bacteria (Martens and Bremner, 1993). Roundup has been shown to be toxic to mycorrhizal fungi in laboratory studies and some damaging effects were seen at concentrations lower than those found in soil following typical applications (Estok *et al*., 1989). Triclopyr was also found to be toxic to several species of mycorrhizal fungi and oxadiazon reduced the number of mycorrhizal fungal spores (Moorman, 1989).

Impacts on non target organisms

The effects of pesticides on target organisms may be less severe to the effects on non target organisms. Most of these organisms are beneficiary and were killed unconsciously by the farmers'. For instance, trifluralin, an active ingredient in the weed-killer Snapshot, "is highly to very highly toxic to both cold and warm water fish" (USEPA, 1996). In a series of different tests it was also shown to cause vertebral deformities in fish (Koyama, 1996). The weed-killers, Ronstar and Roundup are also acutely toxic to fish (Shafiei and Costa, 1990). In addition to direct acute toxicity, some herbicides may produce sublethal effects on fish that lessen their chances for survival and threaten the population as a whole. Glyphosate or glyphosate-containing products can cause sublethal effects such as erratic swimming and difficult breathing, which increase the fish's chance of being eaten (Liong *et al*., 1988). 2,4-D herbicides caused physiological stress responses and reduced the food-gathering abilities of rainbow trout (Little, 1990). Herbicides may hurt insects or spiders also indirectly when they destroy the foliage that these animals need for food and shelter. For example, spider and carabid beetle populations declined when 2,4-D applications destroyed their natural habitat (Asteraki *et al*., 1992). Avitrol, commonly used pigeon bait, poses a large potential for ingestion by non target grain feeding birds. It can be lethal to small seed-eating birds (Extoxnet, 1996).

Impacts on Human

Exposure to pesticides depends on the purpose of its usage. It may be occupational, non occupational, intentional, unintentional or accidental. Also, exposure may be through ingestion (oral), through the skin (dermal) or through inhalation (respiratory). Occupational contamination or poisoning has been identified as the most serious problem associated with the use of agricultural pesticides, especially in developing countries. The inert ingredients and impurities may pose more serious adverse health effects. For example, dioxins may be present as impurities in pesticides while carbon tetrachloride and chloroform often used as inactive ingredients pose substantial risks to the liver and the nervous system (Oluro miniyi and Emily, 2011).

Exposure to pesticides can range from mild skin irritation to birth defects, tumors, genetic changes, blood and nerve disorders, endocrine disruption and even coma or death (Ritter et al., 2007). The immediate symptoms of pesticide contamination include headache, body weakness, blurred vision, vomiting, irritability, impaired concentration and abdominal pain. The chronic effects include; inhibition of human immune system, alteration of acetylcholinesterase glutathione-s-transferase activities, changes in the concentrations of superoxide dismutase and cortisol. The aftermath of the above alterations may lead to reduced sperm counts, blood and liver diseases, depression, asthma, nerve damage and optical impairment.

FACTORS TO BE CONSIDERED WHEN APPLYING PESTICIDES

Quantification

The concentrations of the active ingredient of a pesticide will determine its effectiveness, amount and rate at which they should be applied. All chemical, pesticides inclusive come with recommendations on how much can be safely used and at what intervals. These recommendations are based on experiments that take into account many factors .

However, the mindset that the more the pesticide, the better the result often causes the use of pesticides beyond recommended quantities. The aftermath is the effects on the environment and human.

Application

Pesticides application depends on the medium (liquid, solid or gas) of the pesticide, the area over which the pesticide will be applied and what device is used for application. How a pesticide is applied will affect how free it will be to move in the environment. For instance, a liquid pesticide applied from a large sprayer over a farm field will have different considerations, in terms of transport and fate, than solid pellets of pesticide applied around the foundation of a house. The time at which a pesticide is applied does affect its possible routes of transport in the environment. Most of the considerations for timing are "climatic" or "temporal." This means that they are based upon conditions such as weather or season. For example, a liquid pesticide sprayed from an aerosol can will fall to the ground or move with the air. The amount that moves with the air will depend upon wind conditions. Seasons can affect pesticide transport, as well. Some of the factors that are seasonal are temperature (both inside and outside), humidity, rain and snowmelt.

Nature of the Pesticide

Pesticides vary in the way that they are structured. This is what allows them to "target" certain organisms such as a particular weed or insect. Variance in chemical structure also helps define how a pesticide will move in the environment. Some pesticides are soluble in water, which means that they can move wherever water moves. Some pesticides "volatilize" easily, which means that they can change from a liquid to a gas and move more easily with the air. Other factors of transport and fate of a pesticide to consider when looking at the chemical structure are based on how they will "degrade" or change form in the environment and how long it takes that change to occur. Some pesticides lose their potency when they are degraded and become harmless both to their target organisms and the rest of the environment. Other pesticides may degrade into chemicals that are more toxic than the original chemical. The degradation product(s) may then be toxic to organisms other than the one it was intended for. Pesticides are also degraded at different rates in the environment depending upon their chemical structure. For example, soil organisms might degrade a pesticide within days, whereas another pesticide might take hundreds to thousands of years to degrade. Degradation or transformation of a pesticide results in a change of structure and will change how it moves in the environment (Leonard, 1990).

MITIGATION STRATEGIES TO REDUCE PESTICIDE INPUTS INTO WATER BODIES

To reduce pesticides, input into water bodies the source of diffusion (spray drift, leaching, runoff and erosion) and point source input especially farmyard runoff must be checked.

The following methods of mitigation if adhered to will drastically reduce pesticides loads into water bodies.

i. Use of vegetated buffer strips: the use of vegetated buffer strips along field edges and water bodies (Popov et al., 2005). Grassed waterways, which are frequently established in the United State of America for erosion control, can reduce pesticide runoff and erosion inputs (Asmussen et al., 1977). A grassed waterway is basically a grassed buffer strip installed in up-and-down direction, with surface runoff from the upslope fields directed to it.
ii. Conservation tillage including zero-tillage.
iii. Mulching.
iv. Cover croppings.
v. Contour ploughing / planting.
vi. Application as granules.
vii. Incorporation of the pesticide into the soil.
viii. Avoiding application in seasons with a high probability of occurrence of runoff events.
ix. The use of drift-reducing nozzles and spray additives to coarsen the droplet size distribution, shielded and band sprayers.
x. Spraying on bare floor instead of on crops. This is because spraying on crops leads to higher drift than spraying on bare soil (FOCUS, 2004b).
xi. Crop-free no-spray buffer zones: These are effective in reducing spray drift inputs into surface water bodies (Porskamp et al., 1995).

xii. Reducing the speed of the sprayer. Spray drift increases with driving speed of the sprayer (Arvidsson, 1997).
xiii. Point-source inputs can be mitigated against by increasing awareness of the farmers with regard to pesticide handling and application, and encouraging them to implement loss-reducing measures of “best management practice”.

PRECAUTIONARY MEASURE TO AVOID PESTICIDE TOXICITY

1. Wearing protective clothing and equipment when handling or applying pesticides reduces the risk of pesticide poisoning. Risk of pesticide poisoning is reduced because the chance of exposure is reduced. This idea is expressed by the Risk Formula:

Risk = Toxicity × Exposure

Understanding the toxicity of a product and the potential for personal exposure allows risk to be lowered. No matter how toxic a pesticide is, if the amount of exposure is kept low, risk can be held at an acceptably low level. The toxicity of a pesticide can't be changed, but risk can be managed by the applicator.

2. Be aware of the pesticide toxicity before usage: Nearly all pesticides are toxic. They differ only in the degree of toxicity. Because of this, pesticides are potentially dangerous to people if exposure is excessive. A pesticide product label will have one of three signal words that clearly indicate the degree of toxicity associated with that product. The signal words indicate the degree of potential risk to a user, not the effectiveness of the product. Along with the signal words, pesticide labels also include statements about route of entry and specific actions that must be taken to avoid exposure. Route of entry statements indicate the outcome that can be expected from exposure. For example, a pesticide label might read: "Poisonous if swallowed, inhaled, or absorbed through the skin. Rapidly absorbed through the skin and eyes." This indicates that the pesticide is a potential hazard through all three routes of entry, and that skin and eye contact are particularly hazardous. Specific action statements normally follow the route of entry statement and indicate what must be done to prevent poisoning accidents. In the case of the pesticide discussed above, the statement might read: *"Do not get in eyes, on skin, or on clothing. Do not breathe spray mist."* pesticides can enter the human body three ways: 1) by absorption through the skin or eyes (*dermally*); 2) through the mouth (*orally*); and 3) by breathing into the lungs (*inhalation*).

MINIMIZING THE ABUSE AND MISUSE

The problem of pesticide management in developing countries is somewhat different than those of the developed countries. To reduce the abuse of pesticide, the Government should formulate a policy revolving round the OECD ideology, for instance:

i. Provision of detailed information on pesticides by forming an Extension network to be operated by Federal and State Ministry of Agriculture and Environment. The network is to provide: Pesticide Information Profiles, Toxicology Issues of Concern, Factsheets, News about Toxicology Issues, Newsletters, Resources for Toxicology Information and Technical Information.
ii. Reassessment reflects improved scientific knowledge of pathways, fate and effects of pesticides.
iii. Funding to promote conversion of traditional agriculture to organic agriculture which, by definition, does not use pesticides.
iv. Excise tax on pesticides: A tax on pesticides can be designed and implemented in such a way that it will reduce the use of pesticides without distorting or dramatically worsening the economic situation in the agricultural sector." Funds raised by the tax were to be directed back to the agricultural sector. Studies reported by the Institute of Agriculture suggested, however, that pesticide taxes alone would not produce the requisite reduction during the lifetime of the plan.
v. All farmers and commercial sprayers must hold application certificates. Certification includes education in pesticide issues.
vi. Individual farmers were required to maintain records of pesticide application
vii. Approval of spraying equipment**:** This measure will give the Ministry of Agriculture some control of types of spraying equipment used in Nigeria. New computer controlled sprayers permit continuous monitoring of pesticide dose by the farmer and reduces excessive application.

viii. A strong research and development base that provides credible support for new pesticide initiatives should be developed.
ix. Re-evaluation and re-registration of pesticides used in the developing countries.
x. Prohibiting the use of pesticides within 10 m of lakes, watercourses, wetlands and conservation areas: This would achieve some level of pesticide protection for aquatic systems in the same manner that buffer strips are widely used to reduce the effects of sedimentation.
xi. Prohibiting the use of pesticides within a specified distance from private gardens and properties containing fields that are cultivated without the use of pesticides.
xii. Prohibiting the use of pesticides within 10 m of a drinking-water reservoir.
xiii. Enforcement of pesticide regulations, including importation, use and disposal.

WAYS FORWARD

1. In Nigeria, the Government regulatory body has established maximum contaminant levels (MCLs) for water pollutants. However, there are many uncertainties and complications. The body has not been able to establish drinking water standards for all the pesticides found in water, this is a threat to both public health and environmental integrity.
2. The paper in view of the foregoing therefore, recommends awareness creation as the way forward. This will enable the individual understand how to relate and apply the knowledge of environment to their actions and to the world around him in order to make the environment secure to all.
3. Rural farmers' education on how to apply pesticides and other related inputs should be reemphasized to reduce health hazards involved.
4. The regulatory agencies should provide a simple, easy-to-follow consumer information on the handling, storage and preparation of food.
5. There is a need to do more in the area of enlightenment. Developing countries need to know banned pesticides. At the lowest tier (local government levels), there should be health inspector's officers who should test samples of fruits and vegetables in the market.
6. The water people drink should be well treated and the source monitored regularly. It is regrettable that only about 17.2 per cent of Nigerians have access to clean water (USEPA, 2010). Some people depend on untreated boreholes and wells, some of which are dug close to septic tanks and other high pollutants.
7. People suffering from food poisoning should drink plenty of fluids; eat food that can digest easily and rest very well. Serious cases should be referred to qualified medical personnel.
8. There should be a health enlightenment programme to enlighten citizens on the effects of pesticide residues in order to curb the potential health risk to consumers.
9. Government should set up a task force that would regularly test and monitor the various food grains in markets in order to ascertain their levels of pesticide residue.
10. Moreover, mitigation may be simpler to enforce where no-spray buffers are legislated as no-crop buffers, as in the Netherlands, because the spray operator has no reasons to spray over a no-crop zone.
11. Increasing awareness of the farmers with regard to pesticide handling and application, and encouraging them to implement loss-reducing measures as part of "best management practice.
12. Eradication of all streets hawking of locally adulterated, unregistered, unlabelled, repackaged, uncertified and expired chemical pesticides as well as the need for more stringent monitoring of importation and use of these pesticides in agriculture and food storage in developing countries are required.

CONCLUSION AND RECOMMENDATION

Effect of pesticides contamination is a world-wide problem, but special attention needs to be paid to developing countries. This is because three-fourths of the estimated annual instances of pesticide poisoning and pesticide-related deaths occur in developing countries, and that these countries represent the fastest growing market for agricultural pesticides. Also, the adverse human health effects of pesticide poisoning are particularly high in many of these countries because of the low nutritional status, and the scarcity of health care facilities especially in the rural areas where most of the agricultural activities occur.

Regular monitoring and enlightening of the users is indispensable. This should not be limited to the farmers but to the general public. Radio talks, the use of bill boards and other media should be implored to educate the user of pesticides. Trainings and re-training of extension workers is essential and the use of the local dialect should be encouraged when interacting with the rural farmers.

Pesticide monitoring requires highly flexible field and laboratory programmes that can respond to periods of pesticide application, which can sample the most appropriate medium (water, sediment, biota) that are able to detect the levels that have meaning for human health and ecosystem protection. However, Monitoring data for pesticides are generally poor in developing countries, especially African Countries, though the same trend is observed in some of the developed world. Many developing countries have difficulty carrying out organic chemical analysis due to problems of inadequate facilities, impure reagents and financial constraints. The significance for monitoring is that many newer and soluble pesticides can only be detected shortly after application; therefore, monitoring programmes that are operated on a monthly or quarterly basis (typical of many countries) are unlikely to be able to quantify the presence or determine the significance of pesticides in surface waters.

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