American Journal of Biological and Environmental Statistics
2016; 2(4): 44-49
http://www.sciencepublishinggroup.com/j/ajbes
doi: 10.11648/j.ajbes.20160204.14
ISSN: 2471-9765 (Print); ISSN: 2471-979X (Online)

Revisiting the Environmental Interactions of Pesticides

Phebe Asantewaa Owusu, Samuel Asumadu-Sarkodie*

Sustainable Environment and Energy Systems, Middle East Technical University—Northern Cyprus Campus, Kalkanli, Guzelyurt, Turkey

Email address:

phebeasantewaa@yahoo.com (P. A. Owusu), asumadusarkodiesamuel@yahoo.com (S. Asumadu-Sarkodie)

*Corresponding author

To cite this article:

Phebe Asantewaa Owusu, Samuel Asumadu-Sarkodie. Revisiting the Environmental Interactions of Pesticides. *American Journal of Biological and Environmental Statistics.* Vol. 2, No. 4, 2016, pp. 44-49. doi: 10.11648/j.ajbes.20160204.14

Received: October 6, 2016; **Accepted**: November 10, 2016; **Published**: January 17, 2017

Abstract: As population increases, the demand for safe and nutritious food, safe water and air quality increases. The emergence of pesticides has played as an essential role in preventing pests from destroying various valued properties in our homes, offices and farmlands. The usage of pesticides has a role to play in the achievement of a sustainable developed earth. The earth today needs to be sustainable for future generations, and hence the need to develop it sustainably. The sustainable development aspect consist of the social, economic and environment. The benefits of pesticide in these recent years seem to have been overlooked since the risks associated with its exposure to our health and environment is fatal. As a result, this study revisits the benefits (primary and secondary) of pesticides to man, its economy and environment. The negative effects of pesticide residue exposure in the environment: the atmosphere, soil and water, and how pesticide exposures affect the human system are revisited. Despite the evidence of the adverse effects of the use of pesticides, its usage has increased in the past decades. This paper ascertains the reasons behind the use of pesticides and propose some recommendations to reduce the effects of its exposure.

Keywords: Pesticides, Sustainable Development, Climate Change, Agriculture, Environment

1. Introduction

Global interest in mitigating climate change and its impact has increased within the past decades because of the long-term effect of the greenhouse gas emissions. Scientific contribution to climate change mitigation has increased in the field of energy, agriculture, environment and natural resources [1-12]. Our environment consists of living and non-living components, which interact with each other. Pests have their role they play in the environment, but the majority is destructive in nature. Pesticides are inorganic or organic toxic compounds that are formulated to prevent the destruction of the vegetation of plants (food produce) by pests (weeds, fungi, insects, etc.). Pesticides continue to play a critical role in food production and environmental pollution around the globe. According to the Sustainable Development goal (SDG) 12, target 12.4, it is essential to achieve an environmentally sound management of chemicals and all wastes throughout their lifecycle. In accordance with the agreed international frameworks, and significantly reduce their release into the air, water and soil in order to minimize their adverse effects on human health and the environment by the year 2020 [13-16].

The identification of pests as posing threats to the environment spans from 2500 BC. In attempts to find a solution to the menace, Sulfur was used to repel insects and prevent fungus on crops. In the 15th century, arsenic, mineral oil, mercury and lead were applied to food produce as insecticides. Food producers (Agriculturalists) began the extraction of chemicals from some plants that had developed resistance against some insects that were destroying crops in the 1700's. In the 1900's, Paul Mueller discovered DDT an inorganic chemical produced in the laboratory which proved to be effective in killing insects as an insecticide [17, 18].

The use of pesticide around the globe continues to increase as shown in in Table 1. Table 1 shows the major grouping of pesticides [19]. Pesticide applications were found to have an effect on the non-targeted components (environment and humans) with only about 0.3% of pesticide administered getting to the target pest, which caused concerns to view the

other 99.7% pesticide interactions with the non-target components [20].

Table 1. *Major Pesticide Groups.*

Type	Used Against
Insecticide	Insects and related animals
Herbicide	Weeds
Fungicide	Fungi (Fungal diseases, molds and mushrooms)
Bactericide	Bacteria
Rodenticide	Mice, rats and other rodents
Algaecide	Algae
Nematocide	Nematodes
Acaricide (miticide)	Mites

The paper attempts to examine the various relationships and interactions between the environment at large and pesticides. As a contribution to literature, the study will increase the global debate on ensuring a sustainable consumption and production patterns in the chemical industry. A qualitative research methodology, which includes information, gathered from the actors in the field of the study, journals, articles, and other literature relevant to the study are analyzed and reviewed. As a contribution, the study increases the global debate on the role of pesticides in the environment.

The remainder of the study include; Benefits of pesticides to the environment, the various aspects of the environment (atmosphere, soil and water) and pesticides, pesticides effect in the human body, continual use of pesticides despite negative effects, Integrated Pest management, ways for reducing pesticides negative effects and Conclusion.

2. Pesticides

Pesticides were formulated to aid in the prevention, destruction, deterring of pests in the environment, which were beginning to be a cause for concern. Later it was also realised that in its use trying to help improve the situation it also came with its own concerns of pollution, of which some are banned (Deldrin, DDT, etc.). Pesticides can be grouped in various ways; the following shows the classification of pesticides according to their chemical structure [21]:

- Organochlorine
- Organophosphate
- Carbanates
- Pyrethriods
- Others (Nitro compounds, bipyridyl compounds, sulfur containing compounds and many more)

The table (Table 2) below also shows the classification of pesticides in terms of the toxic level, expressed as its Lethal dose (LD_{50}) in mg/kg.

Table 2. *Classification of Pesticides (Toxicity).*

Divisions	Toxic level	Examples
Class IA	Extremely dangerous	Parathion, Dieldrin
Class IB	Highly dangerous	Eldrin, Dichlorvos
Class II	Moderately hazardous	DDT, Chlordane
Class III	Slightly hazardous	Malathion,

Pesticides have both primary and secondary benefits to our environment. The primary benefits are the most obvious ones and the main reasons why pesticides were manufactured in the first place, while the secondary benefits are indirect and are less noticed or observed since it happens over a long period.

2.1. Primary Benefits

Increase in crop yield: The use of pesticides primarily was to prevent pests and pest diseases from destroying the crop produce. This has helped a lot in reducing crop infestation and inversely increasing crop yield and putting an end to many hunger situations.

Disease control: The use of insecticides has aided in the prevention of many diseases such as Malaria, which is caused by the female anopheles mosquito, the black fly also causing onchocerciasis (river blindness) and others.

Improving food quality and availability: Food is essential for the survival of humankind, hence the need for adequate quality and consumption by man. The crops that are produced when treated with pesticides attain the maximum nutrient content improving food quality. The use of herbicides also prevents weeds from competing with crops for nutrients [13, 22].

2.2. Secondary Benefits

Pesticides in the long term improve productivity by increasing revenue and profit of farmers. It also increases macro-economic benefits of societies, countries and the globe at large by improving export of produce, labor force and employment opportunities. Globally the following are some of the benefits; decline in civil unrest due to food shortage, reducing the pressure on uncropped land, reduction in the emission of greenhouse gases, reduction in the spread of diseases internationally and trees reducing global warming [22].

Human health and life expectancy are improved due to the increase in the nutritional content of food crops. Also, herbicides use to aid in reducing manual and mechanical labor, as well as reducing soil disturbance and moisture from digging.

In the end, pesticides also help in conserving biodiversity. They also help in sports by destroying pests on the pitches and in buildings by protecting building materials, especially wood from being destroyed by pest infestation [13, 22]. Metabolites are produced after pesticides in the environment go through some chemical (photochemical) reactions, which are comparatively non-hazardous to the environment or man [23].

3. Negative Effects of Pesticides on the Environment and Mankind

3.1. Effects in the Soil

Most pesticides are target oriented but sometimes ends up destructing non-target areas like the soil. The soil supports many life forms. Pesticides in soils also do not remain in the

soil, but moves through while some stick to the soil. Although the use of pesticides in some researches has shown to aid in biodiversity, others have also reduced biodiversity in the soil by killing soil invertebrates such as earthworms. These residues also disrupt nutrients in the soil by killing of earthworms and losing their activity benefits as well as soils losing their water retention ability [24, 25].

3.2. Effects on the Atmosphere

The atmosphere is probably an important medium for long-distance dispersal of pesticides. Pesticides can be referred to as semi-volatile organic compounds, which can be transported owing to their aerial or particulate distribution into the atmosphere over wider distances.

Pesticide residue that moves into the atmosphere mixes with other chemicals and may return to the soil surface by rainfall. It gets into the atmosphere by spray application, volatilization from crops or soils, physiochemical properties of pesticides and environmental conditions (humidity, higher air temperature, wind speed and soil temperature) [24, 25].

3.3. Effects on Water

Water supports many life forms like humans, animals, plants and aquatic life [15, 26-28]. Water also serves for recreational purposes. Water pollution by pesticides is mostly by anthropogenic factors. Pesticide residue is a severe source of pollution to water, which affects both surface water and groundwater.

Pesticides gets into these water sources by surface runoff and leaching. The leaching of pesticides to reach groundwater sources depends on soil characteristics, properties of pesticide, depth of water table and drainage rate, while macropores in soil enhances leaching of pesticide residue. If these water sources are affected, it disrupts many life forms that depend on them [20, 24].

Pesticides residue in water bodies such as rivers or lakes, cannot be really measured due to the flow and velocity of water in these bodies, hence they can be measured by assessing its persistence in fish in these sources [29].

3.4. Human System and Pesticides

Humanity benefits a lot from the use of pesticides by various means: the control of vector-borne disease causing organisms, both in man and its livestocks as well as plants that enable man to have adequate food for consumption. However, the negative effects of the use of these pesticides cannot be overlooked or ignored because to a greater extent, it causes a lot of harm [22].

Humans mostly get into contact with pesticides through non-targeted areas unless it is accidental or suicidal. It usually occurs by ingestion through exposure of foods that have pesticide residue, water contaminated with pesticide residue as well as breathing it in and getting onto the skin from atmospheric exposure to pesticides. Food intake is the major medium through which pesticide gets into the human system. The most immediate contact persons to pesticide exposure are farmers and their workers [20, 30]. Aside these major group pesticides affect in one way or the other the wider population. Figure 1 depicts a brief summary of the population groups at risk [31].

The effects of pesticides affect various parts of the human system. A study by Bassil, Vakil [32] revealed a significant relationship between pesticides exposure and the development of some types of cancers namely; brain cancer, prostate cancer and kidney cancers. In addition, Non-Hodgkin Lymphoma (NHL) and Leukemia were prevalent in pesticide exposures. Aside causing cancer, there are other acute and chronic diseases related to a man's exposure depending on the dose of exposure and the duration, it also disrupts sex hormone actions in both men and women [33].

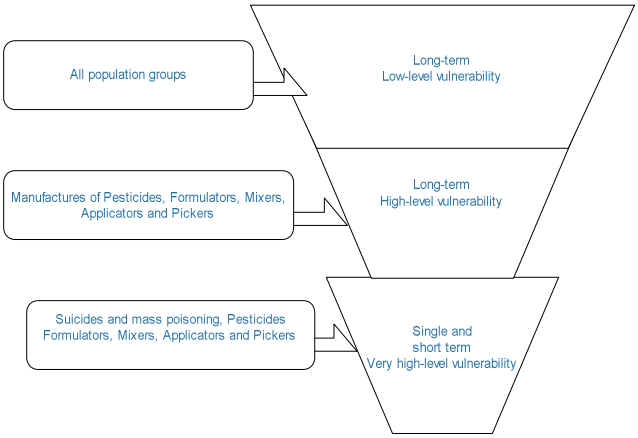

Figure 1. *Population at risk of pesticide vulnerability.*

3.5. The Continual Use of Pesticide by Farmers in Spite of Its Negative Effects

The evidence of the effects on our environment and health of pesticide in most cases is substantiated, but still its use is still ongoing. These are some reasons why farmers continue to use pesticides [34]:

- Cost involved in switching to a more sustainable approach
- Positive profits from pesticide use by increasing yield and productivity
- Market systems, in the notion of farmers that if I do not join in the use of pesticide, I stand to lose a lot. Hence, I should partake in sharing the proceeds.
- Ignorance of some uses
- Underestimation of the various negative effects of pesticide use
- No immediate solution to the prevention of the destruction of food produce by pests.

4. Integrated Pest Management (IPM)

There are several definitions to the explanation of Integrated Pest Management (IPM), but Prokopy defined it as "a decision-based process involving the coordinated use of multiple tactics for optimizing the control of all classes of pests (insects, pathogens, weeds, vertebrates) in an ecologically and

economically sound manner" [35]. IPM was a concept that its implementation or adoption will be able to offer users (farmers) with some degree of economic development and keep both our environment and human health safe.

Integrated Pest Management goals as initially intended, is not being implemented, but has been done by looking at its entity in various aspects. It is in the form of a policy framework being definite and is recognized globally for the management of pest. The fact that it cannot be implemented in its entity means that there are some limitations, which can be as follows [36]:

- Most agriculturalist finds the implementation of Integrated Pest Management as tiring or demanding and complex.
- There is also a conflict of interest on the part of pest control specialists since pesticide manufacturers mostly employ them and they do not have enough time for the monitoring of pest and their natural adversaries.
- Scientist in the pest field of various institutions have being interested in the various individual segments of IPM but not wholly.

5. Reducing the Negative Effects of Pesticide Use

The negative effects of pesticides are reduced through various approaches, innovations and by a collective action being employed. There are bans on some pesticide use such as DDT, and a host of others, which is still in our environment. To really deal with this situation there should be strict measures or policies and its enforcement put into action by opinion leaders and politicians (governments) to help reduce the effects of pesticide in our environment and on humanity.

There should be a broad risk communication and education programs in communities or societies, countries, especially in developing countries, to the dangers that pesticides exposure poses and to the extent of the damaged caused especially in human populations. Aside the education on risks, education on use and safe handling of pesticides needs to be given a lot of attention since most of the exposure are through these (unsafe handing and misuse).

Exposure is reduced by the discontinuation of calendar spraying to reduce the amounts of pesticide in our environment. In addition, the development of sustainable approaches to the use of pesticides, by substituting non-resistant seeds with pest-resistant ones, crop rotation in agricultural farmlands is essential in the control of pests, in order to avoid the use of pesticides.

Farmers or pesticide users have to read and follow label instructions adequately. Before the application of pesticides, protective clothes (gloves, long pants and respirators) have to be used. Leaking equipment should not be used as well as the right measuring equipment used and quantities not over-dosed. Pesticides should be kept safely and most importantly to be kept away from food and hard to reach areas in the home. Biological control of insects or predators, which are harmless to the crops, needs to be adopted. In case of rodent traps can be used instead of the use of pesticide [37-39].

6. Conclusion

Everybody (citizens, politicians, economists and environmentalists) in our world today wants a better future for the generations yet unborn, hence the need to protect our environment and health. Sustainable development has become a relevant issue to be discussed when it was realized by some scientists with evidence, that by the way human populations were increasing and the rate of degradation of our environment there needed to be a sustainable approach being employed.

The use of pesticides became necessary when pests were destroying food crops and some vector disease pests also causing some illness in man and animals that were in most cases detrimental. During these periods pesticides use was sure solution to the problems at hand. It had both primary and secondary benefits. The primary benefits that was immediately noticed as increasing yield, profits to farmers, curbing hunger situations around the globe and preventing some vector-borne diseases such as malaria. In the long run, its secondary benefits also were realized in various sectors like improving human health due to the nutritional quality of food, improving productivity and economic benefits of countries and improving the social well-being of people by killing pests in recreational areas such as pitches and also the killing and prevention of insects in buildings.

In the centuries that followed its negative impact became evident in the environment (soil, atmosphere, water and biota) and health. Pesticide residues in our environment cause decline in biodiversity and the killing of non-target species such as birds. In human health, its exposure is becoming detrimental causing cancers, diabetes, birth defects and a host of other diseases. Various attempts employed include the Integrated Pest Management approach, which was to improve the situation but had its own constraints on the implementation process, with efforts toward its absolute adoption.

In spite of its negative effects, pesticides are still being used extensively and to help improve the situation there are some measures that needs to be adopted to reduce the impact: education, measuring to reduce exposure and researches into substitutes that can help remedy the situation aside using pesticides. In doing this the world can be sustainably developed in the economic, social and environmental aspects. We (humans) can have positive attitudes (behavior change) towards the use of pesticides, which can go a long way to improve the situation.

References

[1] Asumadu-Sarkodie S, Owusu P. The Casual Nexus between Child Mortality Rate, Fertility Rate, GDP, Household Final Consumption Expenditure, and Food Production Index. Cogent Economics & Finance. 2016;4:1191985. http://dx.doi.org/10.1080/23322039.2016.1191985.

[2] Asumadu-Sarkodie S, Owusu PA. Carbon dioxide emissions, GDP, energy use and population growth: a multivariate and

causality analysis for Ghana, 1971-2013. Environmental Science and Pollution Research International. 2016;23:13508–20. http://dx.doi.org/10.1007/s11356-016-6511-x.

[3] Owusu PA, Asumadu-Sarkodie S. Is there a causal effect between agricultural production and carbon dioxide emissions in Ghana? Environmental Engineering Research. 2016; 0: 0. http://dx.doi.org/10.4491/eer.2016.092.

[4] Asumadu-Sarkodie S, Owusu PA. The relationship between carbon dioxide and agriculture in Ghana: a comparison of VECM and ARDL model. Environmental Science and Pollution Research International. 2016;23:10968-82. http://dx.doi.org/10.1007/s11356-016-6252-x

[5] Asumadu-Sarkodie S, Owusu PA. Multivariate co-integration analysis of the Kaya factors in Ghana. Environmental Science and Pollution Research International. 2016; 23:9934-43. http://dx.doi.org/10.1007/s11356-016-6245-9.

[6] Asumadu-Sarkodie S, Owusu PA. Carbon Dioxide Emission, Electricity Consumption, Industrialization and Economic Growth Nexus: The Beninese Case. Energy Sources, Part B: Economics, Planning, and Policy. 2016. http://dx.doi.org/10.1080/15567249.2016.1217286.

[7] Asumadu-Sarkodie S, Owusu PA. A Multivariate Analysis of Carbon Dioxide Emissions, Electricity Consumption, Economic Growth, Financial Development, Industrialization and Urbanization in Senegal. Energy Sources, Part B: Economics, Planning, and Policy. 2016. http://dx.doi.org/10.1080/15567249.2016.1227886.

[8] Asumadu-Sarkodie S, Owusu PA. The Causal Nexus between Carbon Dioxide Emissions and Agricultural Ecosystem, an Econometric Approach. Environmental Science and Pollution Research International. 2016. http://dx.doi.org/10.1007/s11356-016-7908-2.

[9] Asumadu-Sarkodie S, Owusu PA. Energy use, carbon dioxide emissions, GDP, industrialization, financial development, and population, a causal nexus in Sri Lanka: With a subsequent prediction of energy use using neural network. Energy Sources, Part B: Economics, Planning, and Policy. 2016; 11:889-99. http://dx.doi.org/10.1080/15567249.2016.1217285.

[10] Asumadu-Sarkodie S, Owusu PA. The Causal Nexus between Energy Use, Carbon Dioxide Emissions and Macroeconomic Variables in Ghana. Energy Sources, Part B: Economics, Planning, and Policy. 2016. http://dx.doi.org/10.1080/15567249.2016.1225134.

[11] Asumadu-Sarkodie S, Owusu PA. The Causal Effect of Carbon Dioxide Emissions, Electricity Consumption, Economic Growth and Industrialization in Sierra Leone. Energy Sources, Part B: Economics, Planning, and Policy. 2016. http://dx.doi.org/10.1080/15567249.2016.1225135.

[12] Asumadu-Sarkodie S, Owusu PA. The Relationship between Carbon Dioxide Emissions, Electricity Production and Consumption in Ghana. Energy Sources, Part B: Economics, Planning, and Policy. 2016. http://dx.doi.org/10.1080/15567249.2016.1227885.

[13] Aktar W, Sengupta D, Chowdhury A. Impact of pesticides use in agriculture: their benefits and hazards. Interdisciplinary toxicology. 2009; 2:1-12.

[14] United Nations. Sustainable Development Goals. 2016.

[15] Owusu PA, Asumadu-Sarkodie S, Ameyo P. A review of Ghana's water resource management and the future prospect. Cogent Engineering. 2016;3:1164275. http://dx.doi.org10.1080/23311916.2016.1164275

[16] Owusu P, Asumadu-Sarkodie S. A Review of Renewable Energy Sources, Sustainability Issues and Climate Change Mitigation. Cogent Engineering. 2016; 3:1167990. http://dx.doi.org/10.1080/23311916.2016.1167990

[17] Jain H. Green revolution: history, impact and future: THE GREEN REVOLUTION: HISTOR; 2010.

[18] Costa LG. Toxicology of pesticides: A brief history. Toxicology of Pesticides: Springer; 1987. p. 1-10.

[19] The University of Arizona. Pesticide Types and Formulations. Chapter 3: Arizona Agricultural Pesticide Applicator Training Manual, College of Agriculture and Life Sciences 2000.

[20] Van der Werf HM. Assessing the impact of pesticides on the environment. Agriculture, Ecosystems & Environment. 1996; 60:81-96.

[21] Prieto F, Cortés S, Gaytán J, Ceruelos A, Vázquez P. Pesticides: Classification, Uses and Toxicity. Measures of Exposure and Genotoxic Risks. Journal of Research in Environmental Science and Toxicology. 2012; 1:3-23.

[22] Cooper J, Dobson H. The benefits of pesticides to mankind and the environment. Crop Protection. 2007; 26:1337-48.

[23] Kole R, Banerjee H, Bhattacharyya A, Chowdhury A, AdityaChaudhury N. Phototransformation of some pesticides. ChemInform. 2000; 31.

[24] Edwards C. Environmental pollution by pesticides: Springer Science & Business Media; 2013.

[25] Polyrakis IT. Environmental pollution from pesticides. Predictive Modeling and RiskAssessment: Springer; 2009. p. 201-24.

[26] Asumadu-Sarkodie S, Owusu PA, Rufangura P. Impact analysis of flood in Accra, Ghana. Advances in Applied Science Research. 2015; 6:53-78. http://doi.org/10.6084/M9.FIGSHARE.3381460.V1

[27] Asumadu-Sarkodie S, Rufangura P, Jayaweera HM, Owusu PA. Situational Analysis of Flood and Drought in Rwanda. International Journal of Scientific and Engineering Research. 2015; 6:960-70. http://dx.doi.org/10.14299/ijser.2015.08.013

[28] Asumadu-Sarkodie S, Owusu PA, Jayaweera HM. Flood risk management in Ghana: A case study in Accra. Advances in Applied Science Research. 2015; 6:196-201. http://doi.org/10.13140/2.1.4945.7440

[29] Khan M. Pesticides in aquatic environments: Springer Science & Business Media; 2013.

[30] Margni M, Rossier D, Crettaz P, Jolliet O. Life cycle impact assessment of pesticides on human health and ecosystems. Agriculture, Ecosystems & Environment. 2002; 93:379-92.

[31] Jeyaratnam J. Acute pesticide poisoning: a major global health problem. World Health Stat Q. 1990; 43:139-44.

[32] Bassil K, Vakil C, Sanborn M, Cole D, Kaur J, Kerr K. Cancer health effects of pesticides Systematic review. Canadian Family Physician. 2007; 53:1704-11.

[33] Andersen HR, Vinggaard AM, Rasmussen TH, Gjermandsen

IM, Bonefeld-Jørgensen EC. Effects of currently used pesticides in assays for estrogenicity, androgenicity, and aromatase activity in vitro. Toxicology and applied pharmacology. 2002; 179:1-12.

[34] Wilson C, Tisdell C. Why farmers continue to use pesticides despite environmental, health and sustainability costs. Ecological economics. 2001; 39:449-62.

[35] Prokopy RJ. Two decades of bottom-up, ecologically based pest management in a small commercial apple orchard in Massachusetts. Agriculture, Ecosystems & Environment. 2003; 94:299-309.

[36] Ehler LE. Integrated pest management (IPM): definition, historical development and implementation, and the other IPM. Pest management science. 2006; 62:787-9.

[37] Ibitayo O, Monosson E. Agricultural pesticide contamination. Encyclopedia of Earth (Washington, DC: Environmental Information Coalition, National Council for Science and the Environment). 2007.

[38] Fait A, Iversen B, Tiramani M, Visentin S, Maroni M, He F. Preventing health risks from the use of pesticides in agriculture: WHO; 2001.

[39] Subramanyam B, Hagstrum DW. Alternatives to pesticides in stored-product IPM: Springer Science & Business Media; 2012.