

A Synoptic Review on Ecological Toxicology and Environmental Sustainability

Leera Solomon, Victoria Daminabo and Chinedu Azubuike Uzor

Department of Science Laboratory Technology, School of Science and Technology, Port Harcourt Polytechnic, Rumuola, P.M.B. 5936, Port Harcourt, Rivers State
sololeera@yahoo.com

Abstract: Ecotoxicology and environmental sustainability issues was synoptically reviewed. Communities of living things and the environments they live in, form ecosystems. Ecosystems include rivers, ponds, deserts, grassland and forests, all of which can be affected by toxic chemicals. The impact of these toxicants on environment and biodiversity has been of great concern for the last fifty years. Toxicity depends on dose, duration and route of exposure, shape and structure of the pesticides and chemical themselves. Ecotoxicologists study what happens to toxicants themselves, where they go in the environment, how long they last and how they finally breakdown. Toxic agents include heavy metals, solvents and vapours, radiation and radioactive materials, dioxin/furans, pesticides, plant and animal toxins. Introduction of toxic agents into environmental media renders the environment unsustainable. This increasing hostile and unhealthy environment is causing the dislocation, depletion and extinction of biota whose physicochemical properties are self-regulating, self-sustaining and self-perpetuating so that they are maintained in a favourable range for life.

[Solomon, L., Daminabo, V. and Uzor, C.A. **A Synoptic Review on Ecological toxicology and Environmental Sustainability.** *Researcher* 2016;8(12):6-10]. ISSN 1553-9865 (print); ISSN 2163-8950 (online). <http://www.sciencepub.net/researcher>. 2. doi:[10.7537/marsrsj081216.02](https://doi.org/10.7537/marsrsj081216.02).

Keywords: Toxic agents, environmental media, Ecotoxicology, environmental sustainability.

1. Introduction

Sustainability issues arise wherever there is a risk of difficult or irreversible loss of the things or qualities of the environment that people value and, whenever there are such risks, there is a degree of urgency to take action.

Ecotoxicology developed from the need to measure and predict the impact of pollutants on populations, communities and whole ecosystems rather than on individuals. Dr. Ren Truhaut was the first to use the term ecotoxicology around 1969 (Twardowska, 2004; Ramade, 1997).

Further, this field of ecotoxicology studied the effects of anthropogenic chemicals on ecosystems at different levels of biological organization, from the molecular and cellular level to entire ecosystems.

Forbes and Forbes (1994) defined ecotoxicology as the field of study which integrates the ecological and toxicological effects of chemical pollutants on populations, communities and ecosystems with the fate of such pollutants in the environment.

Based on the results of ecotoxicity tests we can predict the effect of chemical substances on humans and on the ecosystem (Walker *et al.*, 1996; Polis, 1999).

Ecotoxicity aims at defining the adverse effect concentration of a chemical substance in the environment. This can be determined from the concentration-response relationship.

Environmental quality criteria should also be based on that (Ezeabasili, 2009). There is three main

objectives in ecotoxicology (Forbes and Forbes, 1994):

- 1) Obtaining data for risk assessment and environmental management.
- 2) Meeting the legal requirements for the development and release of new chemicals into the environment.
- 3) Developing empirical or theoretical principles to improve knowledge of the behaviour and effects of chemicals in living systems.

In order to achieve these objectives, the main areas of study are: the distribution of pollutants in the environment, their entry, movement, storage and transformation within the environment and the effects of pollutants on living organisms (Carson, 1962).

At an individual level, toxicants may disrupt the biochemical, molecular and physiological structure and function which will in turn have consequences for the structure and function of communities and ecosystems.

Whereas at the population level it may be possible to detect changes in the numbers of individuals, in gene frequency (as in resistance of insects to insecticides) or changes in ecosystem function (e.g. soil nitrification) which are attributable to pollution (Fig.1).

Pollution could be defined as the introduction by man into the environment of any material that has detrimental effects on the vital components of the ecosystem (Okpokwasili, 2006; Akpahwe and Solomon, 2012).

Where is Pollution?

- Most near the coast.

- 76% of fish harvested come from the coast.



Fig. 1: Pollution along coastline areas. Adopted from Forbes and Forbes (1994)

Threats to the environment mean that there is a risk that it will not be sustained. It may be possible to use biomarkers to establish that a natural population has been exposed to pollution and these can provide a valuable guide to whether or not a natural population is at risk or in need of further investigation (Clement and Newman, 2002).

For the purposes of the regulation and registration of chemicals the toxicity of individual chemicals is principally investigated via toxicity testing, the main tool of which is the Standard Toxicity Test (STT) which usually tests the dose or concentration of a particular chemical that is toxic to under controlled, laboratory conditions (Forbes and Forbes, 1994).

Toxicity tests are mainly carried out using individual animals although there has been a move towards the use of more complex systems known as mesocosms. In some situations, particularly in the case of pesticides, it may be possible to carry out field trials to assess toxicity.

Toxicity data are used to make assessments of the hazard and risk posed by a particular chemical.

An extensive range of ecotoxicological tests often used includes:

- Bacterial toxicity tests,
- Algal growth tests with a variety of species,
- Acute toxicity tests with *Lemna minor*,
- Acute and reproduction tests in *Daphnia magna*,
- Acute toxicity tests with the marine copepod *Acartia tonsa*,
- Oyster embryo larval toxicity test,
- Acute toxicity test with the marine invertebrate *Mysidopsis bahia*,
- Earthworm toxicity tests,
- Toxicity tests with sediment dwelling organisms such as *Chironomus* or *Lumbriculus*,

- Acute toxicity tests with freshwater and marine fish,
- Acute toxicity tests with shrimps,
- Bioaccumulation in fish.

1.1 Environmental toxicology

It was after World War II that increasing concern about the impact of toxic chemicals on the environment led toxicology to expand from the study of toxic impacts of chemicals on man to that of the environment (Carson, 1962).

This subject became known as Environmental Toxicology. It combines Ecology (scientific study of interactions that determine the distribution and abundance of organisms) and Toxicology (study of injurious effects of substances on living organisms) (Chapman, 2002).

Environmental toxicology is the science and practice of the adverse effects, mainly of chemicals and other man-made agents in the environment and through the environment.

It attempts to anticipate where these substances go in the environment (their fate) and what ecological effects they have when they get there. It aims to characterize the adverse effects of chemical substances on the ecosystem and humans, though we cannot measure these effects directly.

Environmental toxicology depends on laboratory work (effects of toxicants on biochemistry and physiology), field work (field observations of reproduction and survival in polluted versus non-polluted sites) and modeling of fate and transport of toxicants in the environment i.e. exposure and risk assessment:

- Static models : short term modeling of ecosystems.
- Strategic models : model of a specific aspect of a system.
- Testable models : model makes predictions that can be tested in the field or laboratory.

1.2 Purpose of environmental toxicology

1) Description of the fate and transport of chemicals in the biosphere and the organism after the release to the environment.

2) Description of the interaction of the material with the site of action.

3) Description of the impact of this molecular interaction upon the function of the ecosystem (Landis and Yu, 2003).

1.3 Environmental sustainability

The existence of man will continue to register its effects and impacts on the environment. The reasoning in sustainable development is to ensure that our environment is safe for human habitation and to check the adverse effect of emerging environmental problems (Loomis and Hayes, 1996).

To maintain the environment at a life sustaining level with attendant economic development and also have a reserve for the future, the concept of sustainable development was initiated by the Brundtland Commission.

Sustainable development is defined as development that meets the resources and service needs of the present without compromising the ability of the future generation to meet their own needs.

These principles aim at reconciling the apparent conflicts between environmental protection, economic development and the quality of life.

It is relevant at the global, national and local levels as its values for setting the context for policy development and environmental laws (Ajayi, 1995; Costanza *et al.*, 1995).

Today, human activities and the demand for economic growth and development have negatively affected the environment thereby causing land degradation, water pollution and air pollution.

In addition, slums in the cities as a result of urbanization, utter neglect and disregard for the protection of the immediate environment, much more the future environment.

Environmental sustainability could be defined as a condition of balance, resilience and interconnectedness that allows human society to satisfy its needs while neither exceeding the capacity of its supporting ecosystems to continue to regenerate the services necessary to meet those needs nor by our actions diminishing biological diversity (Callicott and Mumford, 1997; Ezeabasili, 2009). Some of the issues that pose major environmental sustainability problems include:

- Destruction of the living environments (habitats) of native species.
- Discharge of polluting chemicals and other materials into the environment.
- Emission of greenhouse gases into the atmosphere that can cause climate change.

- Depletion of low cost oil and other fossil fuels.

Environmental sustainability programs include actions to reduce the use of physical resources, the adoption of a 'recycle everything/buy recycled' approach, the use of renewable rather than depletable resources.

Furthermore, the redesign of production processes and products to eliminate the production of toxic materials and the protection and restoration of natural habitats and environments valued for their livability or beauty (Ajayi, 1995; Ejere, 2003).

These sustainable programs need to operate on an adequate scale and need to continue operating reliably for as long as the threats continue (Umezurike, 2005).

A good way to go about elaborating the environmental sustainability mission is to use a 'backcasting from principles' method to create an anticipatory adaptive management system.

The approach is built around action steps that answer these questions:

A. What preferred conditions do we want/need to achieve?

- What do we care for?
- What needs to be sustained in the physical environment?
 - What needs to be done in society and the economy to prevent environmental sustainability?
 - What needs to be done in the environment to restore environmental sustainability?
 - What form should the anticipatory adaptive-management system take that is to drive the achievement of environmental sustainability?
 - How can development be decoupled from environmental damage?

B. What state are we in now?

- How far are we from achieving the preferred-future system conditions and stretch goals?
- What strong dynamics/mechanisms are in place already to move us to achieve the preferred future?
 - What strong dynamics/mechanisms are in place already that will move us away from or block a movement to the preferred future?
 - What is the likely result of the interplay of these dynamics/mechanisms? i.e., what is our current sustainability-effectiveness?

C. How do we get to there from here, with the least loss along the way?

- How do we close the gap between where we are now and where we want to be?
- How do we create changes of right sort and the right scale and speed?

- How do we minimize the losses on the way to achieving sustainability?
- What changes are needed across society (especially system transformation)?
- What changes need to be made within organizations and by individuals?
- How do we account for the fact that society has more goals than sustainability? How do we make sure that sustainability is not pushed to the sidelines while society deals with other important issues?
- What scenarios, options and solutions can we generate?

D. What should we do right now?

- What can we do to begin implementing our action plans?
- Are the actions that we plan to take going to advance all our main goals? Or do we need to coordinate and combine actions to cancel out or prevent any negative effects across our goals?
- How can we prepare the ground for the next wave of actions?
- How can we increase our capacity to be effective in the future?

1.4 Carson's contribution

Prior to the 1960s, there were no coordinated programmes in research, in education or in regulation that systematically addressed toxic substances in the environment.

Most workers in the field of ecotoxicology refer to the publication of Rachel Carson's *Silent Spring* (1962) as a landmark in the public's awareness of potential damage to human and environmental health from man-made toxic substances. Carson's contribution:

"Carson's book created modern society's fears about synthetic chemicals in the environment and, among other things, fostered renewed interest in the science of toxicology".

Rachel Carson (1907-1964) was a Marine Biologist from Pennsylvania. She was disturbed by the widespread and indiscriminate use of pesticides.

Many of these pesticides were known to affect wildlife e.g. kill birds. She lobbied very hard to control and ban certain highly toxic chemicals.

She testified before congress in 1963 and called for new policies with respect to human health and the environment.

1.5 Summary

The environment is the source of energy and materials which mankind transforms into goods and services to meet his daily needs.

It also acts as a vast sink for the wastes and polluting substances he generates. The goal of environmental sustainability is to halt environmental degradation and support healthy citizenry.

An "unsustainable situation" occurs when natural capital (the sum total of nature's resources) is used up faster than it can be replenished.

Sustainability requires that human activity only uses nature's resources at a rate at which they can be replenished naturally. Inherently, the concept of environmental sustainability is undermined with the concept of carrying capacity.

Theoretically, the long-term result of environmental degradation is the inability to sustain ecosystem. Such degradation on a global scale could imply extinction and loss of ecological diversity (including beta, gamma and alpha diversity).

1.6 Conclusion

A toxicant is any chemical that can injure or kill ecotype; a poison. The word "toxicity" describes the degree to which a substance is poisonous or can cause injury.

It is the responsibility of all of us to pay particular attention to protect the environment by ensuring that we avoid anything that might destroy it and at the same time obey rules and regulations that will help sustain the environment.

1.7 Recommendations

A full sustainability program needs to include concise actions geared towards preventing threats and impacts from arising; actions to protect the environment from threats, damages and restoration to reverse the damages already done.

Acknowledgements:

Authors are grateful to Rachel Carson and the Nigerian Environmental Society for encouraging and supporting environmental laws and practices to ensure a healthy lifestyle of the citizenry across the globe.

Corresponding Author:

Solomon, Leera
Department of Science Laboratory Technology,
School of Science and Technology, Port Harcourt
Polytechnic Rumuola, P.M.B. 5936, Port Harcourt,
Rivers State, Nigeria.
E-mail: sololeera@yahoo.com
Tel.: +2348067973111

References

1. Akpahwe, L. and L. Solomon (2012). Crude Oil Theft and its Environmental Consequences: The Way Forward. Paper presented at the 22nd AGM/Annual Conference of the *Nigerian Environmental Society* (NES), Yenagoa, 6- 8th December.
2. Ajayi, W. (1995). Achieving environmental protection through the vehicle of human right: some conceptual legal and third world problems. *University of Benin Law Journal*, 2 (1): 41.

3. Bulich, A.A. and D.L. Isenberg (1981). Use of the luminescent bacterial system for the rapid assessment of aquatic toxicity. *ISA Trans.* 20(1), 29–33.
4. Chapman, P.M. (2002). Integrating toxicology and ecology: putting the eco into ecotoxicology. *Marine Pollution Bulletin*, 44: 7-15.
5. Callicott, J. B. and K. Mumford (1997). Ecological sustainability as a conservation concept. *Conservation Biology*, 11.1: 32-40.
6. Costanza, R. and C. P. Bernard (1995). Defining and predicting sustainability. *Ecological Economics*, 15: 193-196.
7. Carson, R. (1962). *Silent Spring*. Cambridge, Mass. Riverside Press. 257.
8. Clement, W.H. and M.C. Newman (2002). *Community Ecotoxicology*, John Wiley & Sons: Chichester, UK. 336.
9. Ezeabasili, N. (2009). Legal mechanisms for achieving environmental sustainability in Nigeria. *African Research Review*, 3 (2): 369-380.
10. Ejere, O.D. (2003). Sustainable development. A panacea to environmental pollution. *Ambrose Alli University Law Journal*, 1 (2): 79-93.
11. Forbes, V. E. and T.L. Forbes (1994). *Ecotoxicology in Theory and Practice*. Chapman & Hall Ecotoxicology Series 2: London. 674
12. Loomis, T.A. and A.W. Hayes (1996). *Essential of Toxicology*. 4th Edition. San Diego, Academic Press. 282.
13. Landis, W.G. and M.H. Yu (2003). *Introduction to Environmental Toxicology: Impact of Chemicals Upon Ecological Systems*. Third edition. Lewis Publishers CRC Press LLC, New York, USA. 543-549.
14. Okpokwasili, G.C. (2006). Microbes and the environmental challenge. University of Port Harcourt Inaugural Lecture Series, Inaugural Lecture No. 53, 30th November, 2006.
15. Odokuma, L. O. (2012). The genius in the microbe: an indispensable tool for the management of xenobiotic mediated environmental flux. Inaugural Lecture Series No. 87. 14th June, 2012.
16. Twardowska, I. (2004). Ecotoxicology, environmental safety and sustainable development-challenges of the third millennium. *Ecotoxicology and Environmental Safety*, 58: 3-6.
17. Umezurike, U.O. (2005). *Introduction to International Law*. Ibadan: Spectrum Books Limited, 252-259.
18. Walker, C. H., S.P. Hopkin, R.M. Sibly and D.B. Peakall (1996). *Principles of Ecotoxicology*. Taylor & Francis: London, 321.

12/11/2016