

Boon or Bane? The Environmental and Health Impacts of Persistent Organic Pollutants (POPs)

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Abstract

This article examines the relationship between environmental pollution and health problems affecting human and non-human species. Specifically, it reviews existing evidence on Persistent Organic Pollutants (POPs) — a class of synthetic organo-chlorine chemicals and products introduced after World War II — and their adverse health effects on society and wildlife. Their fundamental characteristics, including toxicity, persistence, ability to migrate long distances, and bioaccumulation within the food chain, are presented. The reactions of international community, especially the U.N. Stockholm Convention on POPs recently signed by 122 countries, are discussed. The future needs of substitutes to harmful chemicals and mitigation of health problems already caused are discussed as well. The use of precautionary principles as a guide to public health and environmental policies is emphasized.

Keywords: *bioaccumulation, environment, grasshoppers effect, human health, organochlorines, persistent organic pollutants (POPs), precautionary principle, toxic chemicals, risks*

Introduction

The environment, defined as all the biotic and abiotic factors surrounding a given population, has a significant influence on the health and well-being of a population. In fact, the principal factor driving the concerns about environmental quality is its connection to human health. Directly through exposure to xenobiotics and indirectly through systemic environmental events, many health problems are inextricably connected to environmental factors (Smith 2001). Different aspects of the environment — including the biological (biotic), physical (abiotic), social, cultural, and technological factors affect the health status of human population as well as other species within the ecosystems. Evidence in the literature suggests that environmental pollution and ecological degradation have a tremendous negative impact on peo-

ple's well-being (Yassi et al. 2001). Polluted environments increase the probability or risk of exposure to contaminants, disease vectors, and other agents that may induce illnesses both for human and non-human species. POPs represent a significant threat to the environment and health of all organisms including humans.

The purpose of this paper is to address the health and environmental problems related to synthetic toxic chemical compounds, especially, the key POPs of increasing concern at the local, national, and global levels. The fundamental properties of these chemicals and established and potential health problems associated with each compound are discussed. The application of the precautionary principle by the international community to restrict or completely ban these chemicals or place stringent regulatory measures on them will also be discussed in the latter part of this article. Following the introduction, background literature about the paradoxical benefits and risks of science and technology is discussed. Next, the basic properties of POPs are reviewed. The subsequent section is devoted to the pathways of exposure and health problems associated with POPs. The last section focuses on the precautionary principle as a policy tool and the Stockholm Convention on POPs, followed by summary and concluding remarks.

The Paradox of Technological Prowess, Health, and Environmental Risks

Even though environmental hazards and risks have always been present in societies, the technological and chemical revolutions of the 19th and 20th centuries have increased the levels of toxic materials and associated health problems to an unprecedented level in human history (Beck 1992; Epstein, Brown and Pope 1982; Thornton 2000; Graham and Miller 2001). Scientific and technological breakthroughs in the synthesis, production, and release of heterogeneous toxic chemical compounds have contributed to remarkable prosperity on one hand and on the other hand, new arrays of unexpected dreadful health problems have been introduced by these chemicals. The case of POPs such as DDT in particular is paradoxical; while millions of lives have been saved

through its application to control malaria, several millions have also suffered serious adverse health effects from acute and chronic exposures and toxicity (see Epstein, Brown and Pope 1982; Carson 1962; Wargo 1996; Jones and deVoogt 1999; Crinnion 2000; Thornton 2000; McGinn 2002).

In our anthropocentric quests to conquer and subdue nature, arrest infectious agents, exterminate unwanted/undesirable species, and extend the carrying capacity of the Earth, synthetic organic chemical compounds were introduced shortly after World War II.² For more than half a century, a wide array of synthetic organic chemical compounds have been released into the environment. Most of these chemicals were initially greeted with enthusiasm and praised as “modern miracle or boon” due to their effectiveness in controlling pests, improving agricultural yields, increasing the aesthetics of lawns and gardens, and their versatility in various industrial applications. It was not long until Rachel Carson (1962) sounded the alarms about the toxic and persistent nature of these chemicals and their adverse health effects on the ecosystem. Carson poignantly emphasized that:

The central problem of our age has become the contamination of our total environment with such substances of incredible potential for harm — substances that accumulate in the tissues of plants and animals and even penetrate the germ cells to shatter or alter the very material of heredity upon which the shape of the future depends. (1962, 8)

Thus, as indicated by Crinnion (2000), the 20th century with its promise of prosperity and better quality of life, through the application of science and technology, also brought a host of toxic chemical-related disasters, illnesses and associated human sufferings. Kai Erickson (1994) summed these up in his book titled *A New Species of Trouble*.

As noted by Myers (2002, 4), scientific knowledge of the impacts of toxic chemicals on health and the environment lags behind our knowledge and ability to synthesize these chemicals. Furthermore, traditional risk assessment is limited because it permits commercialization, distribution and use of these products without a complete understanding of their adverse effects. Among the consequential problems are pervasive environmental contamination and diminution of human health after exposure. Epidemiology as a tool for developing protective standards is also limited by the fact that it is only applicable *ex post facto*, i.e., after an epidemic has already occurred. Also, it is strongly biased toward negative results, contrary to what popular epidemiology or lay public might suggest.

A growing number of scientists, international organizations, and non-governmental organizations (NGOs) have devoted a considerable amount of time, efforts, and energy to addressing the hazards and risks posed by persistent organic

compounds (see Colborn, Dumanoski and Myers 1996; Jones and deVoogt 1999; Wania and MacKay 1996, 1999; Baskin, Himes and Colborn 2001; Thornton 2000; Lallas 2001, 2002; Schafer, Kegley and Patton 2001; Yassi, et al. 2001; WWF 1999; The World Bank and CIDA 2001). For the past three decades, health problems associated with toxic chemical releases into the environment have been a growing major concern in societies across the globe. Specific cases of toxic chemical contamination which have raised people’s level of concern range from the episodes at the Love Canal, New York, Woburn, Massachusetts, and the accumulation of toxic substances in the Great Lakes and in the Cancer Corridor of Louisiana, to pesticide poisonings in Costa Rica, the accidental releases of dioxin in Seveso, Italy in 1976, and similar contamination in Times Beach Missouri in the early 1980s, to toxic chemical disaster at a Union Carbide pesticide plant in Bhopal, India in 1986 which killed more than 2,000 and injured over 100,000 people, and to toxic chemical contamination in Koko, Nigeria in the late 1980s (see Levin 1982; Epstein, Brown and Pope 1982; Wargo 1996; Brown and Mikkelsen 1990; Adeola 1996, 2000).

In a foreword to *Our Stolen Future*, former Vice-President of the United States Al Gore indicates that Colborn, Dumanoski, and Myers (1996) build upon the work of Carson by reviewing a comprehensive and growing body of scientific evidence linking synthetic organic chemicals to a wide array of terrible health problems. Specifically, the “endocrine disruption hypothesis” and reviewed evidence that synthetic chemicals were acting like the hormone estrogen and causing reproductive and behavioral pathologies in humans and wildlife were publicized (see Baskin, Himes and Colborn 2001; Colburn, Dumanoski and Myers 1996; Wargo 1996). The health effects of these chemicals are discussed in greater details in the latter part of this article.

The Basic Characteristics of POPs

For more than half a century of extensive production, use, and release, POPs are now ubiquitous in the air, soil, and water. The major sources of air pollution contributing to the accumulation of POPs include the manufacture and use of certain pesticides, the production and use of certain toxic chemicals, and the unintentional formation of certain byproducts of incineration, combustion, metal production and mobile sources (Ballschmitter et al. 2002, 274). There is hardly any biomes and species on earth left untouched by these chemicals. Scientific evidence suggests that all living organisms on earth presently carry measurable levels of POPs and related chemicals in their bodies. For instance, POPs have been found in marine mammals at levels concentrated enough to classify their bodies as hazardous waste. Scientists

have reported evidence of POPs contamination in our food, human blood, and breast milk (see Solomon and Schettler 1999; Colburn, Dumanoski and Myers 1996; Wargo 1996; Wania and Mackay 1996; Schafer, Kegley and Patton 2001).

By their nature, POPs are organo-chlorine compounds with extensive longevity in the environment. They represent one of the most harmful classes of pollutants manufactured and released into the environment by humans and as such, they are of particular relevance to human health and the health of other organisms in the environment (Moser and McLachlan 2001). As noted by Eckley (2001, 26), POPs are characterized by their persistence in the environment with a tendency to bioaccumulate in the food chain and their capacity for a long-range, trans-boundary dispersion, posing a great threat to human health and the environment globally. A

list of the 12 most dangerous POPs is presented in Table 1, including aldrin, chlordane, dichloro-diphenyl-trichloro-ethane (DDT), dieldrin, endrin, heptachlor, hexachloro-benzene (HCB), mirex, toxaphane, polychlorinated biphenyls (PCBs), dioxins, and furans, collectively referred to as the “dirty dozen.”³ Their uses, longevity (half-life), and known health effects are also displayed in the table.

The specific characteristics of POPs that warrant increased concern and the need to take immediate precautionary measures to ban or restrict further production and use of these chemicals by the world community include their extensive half-life (persistence), toxicity, lipophilic (fat-soluble), and bio-accumulative properties as well as their ability to travel across the globe. These properties are elaborated in the following sections.

Table 1. Top priority POPs: Uses and their adverse health effects.

| Class | Chemical | Uses | Half-Life in Soil (Years) | Adverse Health Effects |
|---|-------------------------------|---------------------------------|---------------------------|--|
| A. Agricultural and Landscape Chemicals: Pesticides | 1. Aldrin | Insecticide | N/A | Carcinogenic, malaise, dizziness and nausea |
| | 2. Chlordane | Insect and termite control | 1 | Carcinogenic |
| | 3. DDT | Insecticide | 10-15 | Cancer of liver, immune system suppression |
| | 4. Dieldrin | Insecticide | 5 | Liver and biliary cancer |
| | 5. Endrin | Insecticide, rodenticide | up to 12 | Cancers |
| | 6. Heptachlor | Insect and termite control | up to 2 | Cancers, mutations, stillbirths, birth defects, liver disease |
| | 7. Hexachloro-benzene (HCB) | Fungicide | 2.7-22.9 | Cancers, mutations, birth defects, fetal and embryo toxicity, nervous disorder, liver disease |
| | 8. Mirex termiticide | Insecticide, | up to 10 | Acute toxicity, possible cancers |
| | 9. Toxaphene | Insecticide | 3 months to 12 | Carcinogenic, chromosome aberrations, liver and kidney problems |
| B. Industrial Chemicals: | 10. Polychlorinated biphenyls | Industry manufacture, co-planar | 10 days to 1.5 years | Cancers mutations, births defects, fetal and embryo toxicity, neurological disorder and liver damage |
| | 11. Dioxins | By-product | 10-12 | Peripheral neuropathis, fatigue, depression, liver disease, embryo toxicity |
| | 12. Furans | By-product | 10-12 | Peripheral neuropathis, embryo toxicity, liver problems |

Sources: Adapted from Epstein, Brown and Pope (1982, 415-27); UNEP 2000; The World Bank and CIDA 2001.

Toxicity and Longevity

POPs are extremely toxic chemicals with acute and chronic effects on pests, wildlife, and humans upon exposure. In fact, toxicity was their original virtue. Partly due to their toxicity, these chemicals resist breakdown by the natural processes and as such, remain within the environment for a long duration. As shown in Table 1, most POPs persist in the environment for up to 23 years or more (some may take as long as a century to breakdown completely). For instance, chemical compounds such as DDT, endrin, HBC, mirex, polychlorinated-dibenzo-p-dioxins and furans (a product of incomplete combustion), remain toxic and active for approximately 10 to 23 years in the soil, fatty tissue, and other environmental medium (see Wania and Mackay 1996; Epstein, Brown and Pope 1982; Eckley 2001; Jones and deVoogt 1999). Even though the major 12 POPs have now been banned or restricted in most industrialized countries, these chemicals continue to be produced and exported to Third World countries where regulations are lax. However, the “circle of poison” thesis suggests that what goes around, comes around and POPs in particular, do not respect boundaries (Weir and Schapiro 1991).

Lipophilic and Bioaccumulative Properties

POPs are hydrophobic and lipophilic — i.e., they are fat-soluble while resisting breakdown in water. Their lipophilic tendency enables them to concentrate in fatty tissues of organism and bioaccumulate up in the food chain. As noted by Eckley (2001, 28), the levels of POPs detected in organisms that are high on the trophic levels — such as seals, polar bear, predatory birds, mammals, and humans, are sometimes thousands of times higher than levels found in the immediate surroundings (also see Wania and Mackay 1999). Biomagnification is an increase in the concentration of POPs and other organo-chlorinated chemicals in organisms as they pass through the food chain.

The Grasshoppers Syndrome

POPs are known to be highly mobile, traveling long distances even to the remote corner of the Earth (see Koziol and Pudykiewicz 2001; Eckley 2001; Wania and Mackay 1996). They exhibit a process known as the “grasshopper effect,” in which these chemicals go through cycles of volatilizations and condensations — i.e., evaporation and atmospheric cycling in warmer climates and condensation and deposition in colder climates, thus moving these chemicals to remote regions where they have never been produced or used. Colborn, Dumanoski and Myers state that:

These synthetic chemicals move everywhere, even through the placental barrier and into the womb, exposing the unborn during the most vulnerable

stages of development.... When a new mother breast feeds her baby, she is giving him/her more than love and nourishment — she is passing on high doses of persistent chemicals as well. (1996, 106)

POPs tend to reach their highest level of concentrations in the cooler regions of the globe. The indigenous people of the Arctic who depend on traditional diet composed of foods with high fat content are especially at risk of POPs contamination and the resultant adverse health effects. Virtually all living organisms in any parts of the globe now carry detectable levels of POPs in their tissues. As stated earlier, there is a growing evidence of POPs contamination of our foods, human blood and breast milk (Colborn, Dumanoski and Myers 1996; Thornton 2000; Schafer, Kegley and Patton 2001). Even though establishing a direct one-on-one cause and effects of a specific xenobiotic and the resultant adverse health conditions is contentious among experts, scientists, and lay people, some major health problems associated with POPs and other related toxic chemicals have been documented in the literature (see Colborn, Dumanoski and Myers 1996; Thornton 2000; Solomon and Schettler 1999; WWF 1999; Eckley 2001; Smith 2001; Myers 2002).

Exposure Pathways and Health Problems Associated with POPs

Given their ubiquity and persistence in the environment, there is no safe place for escaping POPs contamination. Typical routes of exposure include workplace (in agriculture and industries), dietary exposure, and direct contact with contaminants in the air, buildings, water, lawns, parks, and soil, including but not limited to accidental releases (Lallas 2000/2001, 2002). Pervasive harms to both wildlife and humans by POPs have been documented extensively in the literature. For the former, adverse effects of POPs and related toxic chemicals range from egg shell aberration in birds to extinction of certain bird species (Carson 1962; Colborn, Dumanoski and Myers 1996; WWF 1999); other serious effects include cancers, twisted spines and skeletal deformations, and death of beluga whales. In Florida’s Lake Apoka, stunted penis, hormone disruption, and reproductive failure have been found among alligators — disrupted reproductive development, deformity, immunotoxicity, hormonal deficiencies, to overall population decimation have been reported (Abelsohn et al. 2002; Jones and de Voogt 1999; WWF 1999; Swan, Elkin and Fenster 1997).

For humans, the litany of health problems related to POPs contamination is quite extensive including allergies, birth defects, cancers, embryo toxicity, endocrine (hormone) disruptions, decreased sperm count, diabetes, hypersensitivity, hypospadias (an arrested development of the urethra,

foreskin, and ventral aspect of the penis), kidney and liver dysfunctions, learning and behavioral problems (especially among children), mutations, nervous disorders, premature births, and still births (Hauser et al. 2002; Swan, Elkin and Fenster 2000; Guillette et al. 1998; Baskin, Himes and Colborn 2001; Thornton 2000). Children and infants are particularly more vulnerable than adults to the adverse effects of POPs. Wargo (1996, 11) notes that children and infants seem to be especially vulnerable to carcinogens during periods when their cells are normally developing most rapidly, generally between conception and age five.

The last column of Table 1 shows a partial list of specific adverse health effects of selected POPs.⁴ In a review of 101 studies published between 1934 and 1996, Swan, Elkin and Fenster (2000, 964) note the basic finding of a 50% decline in sperm count among U.S./Canadian, European/Australian men but not among non-Western men. Similar findings of an association between certain POPs such as PCBs, *p,p'*-DDE and abnormal sperm count, motility, and morphology among 29 subjects recruited from Massachusetts General Hospital Andrology Laboratory was recently reported in the journal *Environmental Health Perspectives* by Hauser et al. (2002).

An evaluation of POPs residue data from several reputable sources produced some startling findings. In the U.S. Food and Drug Administration (FDA) residue monitoring in 1999, POPs residues were detected in several food items grown and consumed locally as well those imported from abroad in the U.S. Table 2 shows the top ten foods mostly contaminated by specific POPs.⁵ Residues were found in virtually all food categories including baked goods, fruits, vegetables, meat, poultry, and dairy products. The exposure per day was highest in the southeast of the U.S. (70) and lowest in the mid-west (63). Table 3 presents the number of food items analyzed in the Total Diet Study conducted by the FDA, and the findings of POPs and pesticides residues in

terms of number and percentage of occurrence.⁶ These findings seem instrumental to the Bush Administration's support of the Stockholm Convention on Persistent Organic Pollutants.

The Precautionary Principle and International Agreement on POPs

In the U.S. and other industrialized nations, toxic chemicals are being produced and released at a much faster pace than the enactment of laws that are supposed to regulate them (Adeola 2002). Many new chemicals are persistent, deadly, and trans-boundary in nature that international laws and cooperation are required to regulate them. The precautionary principle is now being advocated both in the U.S. and across the globe. This principle suggests that whenever there is scientific uncertainty about the safety or potentially serious harm from chemicals or technologies, manufacturers or decision makers shall do everything possible to prevent harm to humans and the environment. It stipulates that when an activity raises threats of harm to human health or the environment, precautionary measures should be implemented even if some "cause" and "effect" relationships have not been fully established (Raffensperger 2003, 4). In other words, "it is better to be safe than sorry," and manufacturers of toxic chemicals should be held accountable for any serious adverse health effects of these chemicals to humans and the environment. Environmentalists and other scholars interpret this principle to suggest that if any uncertainty exists about the safety of a technology, it ought to be strictly restricted or banned. Absolute safety to humans and the environment is required of any technology under the precautionary principle (see Goklany 2001).

The aspiration of many advocates of the precautionary principle (a restatement of a popular rendition of the Hippocratic Oath — "first do no harm") is to have it become

Table 2. Top 10 foods most contaminated with POPs.

| Food Items | POP Chemicals | | | | | | | | |
|-----------------------|---------------|-----|-----|----------|--------|--------|-------------|-----|-----------|
| | Chlordane | DDE | DDT | Dieldrin | Dioxin | Endrin | Heptachloro | HCB | Toxaphene |
| Butter | * | * | * | * | * | | * | * | |
| Cantaloupe | | * | | * | * | | * | | * |
| Cucumbers/ Pickles | * | * | | * | | * | * | | * |
| Meatloaf | | * | | * | * | | * | * | |
| Peanuts | | * | | * | | | | * | * |
| Popcorn | * | | | * | | | | | * |
| Radishes | * | | * | * | | * | | | * |
| Spinach | | * | * | * | | | * | | * |
| Summer Squash | * | * | | * | | * | | * | * |
| Winter Squash | * | * | | * | | * | | * | * |

Sources: Schectiter, et al. 1994; FDA 2000; EPA 1994.

Table 3. POPs pesticides found in Total Diet Study in 1999.

| Pesticide | Frequency of Occurrence of Pesticide Residues | |
|--------------------------|---|--------------|
| | Total No. of Findings | % Occurrence |
| DDT* | 225 | 22 |
| Chlorpyrifos-methyl | 188 | 18 |
| Malathion | 175 | 17 |
| Endosulfan | 151 | 15 |
| Dieldrin* | 145 | 14 |
| Chlorpyrifos | 93 | 9 |
| Chlorpropham | 70 | 7 |
| Permethrin | 54 | 5 |
| Iprodione | 48 | 5 |
| Chlordane* | 36 | 3 |
| Heptachlor* | 36 | 3 |
| Lindane | 33 | 3 |
| Thiabendazole | 33 | 3 |
| BHC, alpha+beta+delta | 32 | 3 |
| Hexachlorobenzene (HCB)* | 32 | 3 |

Source: FDA 1999.

*POPs recently banned by the Stockholm International Treaty.

a cornerstone for constructing public health and environmental policies. From a critical perspective, Goklany (2001) argues that taking an absolutist stance in the presence of uncertainty as required by the precautionary principle may also produce unintended consequences. Attempting to solve one problem through a restriction or a complete ban of a given technology in the absence of a substitute may create more serious problems as is the case with DDT in developing countries. It is especially important to make sure that policies derived from the precautionary principle are not counterproductive for public health and the environment. Thus, a universal standardized policies and regulations of certain POPs may be counterintuitive.

To make sure that good intentions do not yield unintended negative outcomes, Goklany (2001, 8-10) offers a framework that would allow the precautionary principle to be used in situations where the overall result might be ambiguous in terms of positive and negative impacts of a policy choice. The framework consists of a set of hierarchical criteria that can be employed to rank the various threats raised or diminished by a given policy based on the nature, magnitude, immediacy, uncertainty, and persistence of each threat, and the extent to which it can be minimized or eliminated. This framework is anthropocentric in the sense that threats to human health and well-being take precedence over threats to the environment and non-human species. More specifically, the following criteria are suggested within a framework:

1. *The Public Health Criterion.* This criterion suggests that morbidity and mortality threats to human beings should outweigh similar threats to members of other species and other non-mortal threats to human health

should be given priority over threats to the environment (with exceptions based on the nature, severity, and magnitude of the threat).

2. *The Acute vs. Chronic Threats Criterion.* Immediate attention should be given to acute threats over threats that could occur in the distant future.
3. *The Uncertainty Criterion.* This implies that threats of harm with higher probabilities of occurrence should take precedence over those with lower probabilities.
4. *The Expectation-Value Criterion.* When confronted with threats that are equally certain, precedence should be accorded those that have a higher expectation value. For instance, an action yielding fewer expected casualties should be preferred over the one producing mass casualties.
5. *The Adaptation Criterion.* If technologies are available to address or manage the adverse outcomes of an impact, then the impact can be discounted in as much as people are able to cope and adapt to the situation.
6. *The Irreversibility Criterion.* Much greater priority should be given to outcomes that are persistent and irreversible.

Other scholars have suggested that implementing precautionary measures that impose more stringent requirements on old and new chemical products is absolutely imperative. The following criteria recognized by the Swedish Chemicals Policy Committee have been suggested in the literature (Myers 2002, 4; Fredholm 2000).

- Complete elimination of persistent bio-accumulative compounds even without demonstrating their toxicological risks.
- Removal of endocrine-disrupting compounds from consumer products and phasing out their environmental release.
- Introduction of a new approach in which safety is assured beyond any reasonable doubt prior to the introduction, distribution, and mass use of toxic chemical products.

The Stockholm Convention on POPs

At a conference in Stockholm, Sweden in May 2001, the international community adopted the new Stockholm Convention on POPs. At that time, more than 90 countries signed the convention and Canada was the first to ratify it. This convention has been signed by more than 122 countries as of March 18, 2002 and it is based upon the precautionary principle which reflects some of the criteria aforementioned. Specifically, the convention is designed to protect human health and the environment from POPs which have become a

prominent global problem. The convention asks its member countries to ban the 12 POPs aforementioned and eliminate or restrict the use of other toxic chemicals that are proven to have the properties of POPs. Also, members are required to take strong measures to prevent or control the release of certain POPs formed as by-products of various industrial combustion activities, and to ensure the safe and proper disposal of such substances when they become waste.

Furthermore, provisions were made to add new chemicals to the list of banned POPs. This convention was structured to address POPs that are intentionally manufactured such as pesticides, insecticides, rodenticides, and fungicides and those produced intentionally and whose use is restricted to disease vector control (e.g., DDT for controlling mosquitoes causing malaria), and those produced and released by accidents due to human activities such as dioxins, furans, PCBs, and HCB (The World Bank and CIDA 2001). Countries are required to make determined efforts to identify, label, and remove PCB-containing equipment from use by 2025, and manage those wastes in an environmentally sound manner no later than 2028. Stockpiles and wastes containing POPs must be managed and disposed of in a safe, efficient, and environmentally sound manner, taking into account international norms, standards, and guidelines. Also, to ensure implementation of various articles of the convention, provisions were made for information exchange and increasing public awareness and education about the adverse health effects of POPs.

Summary and Conclusions

As a result of accelerated production, use, and release of heterogeneous synthetic organo-chlorine chemicals over the last 60 years, humans and wildlife are now struggling with multiple environmental contaminants. POPs represent the major culprit for most pollutants and health problems reviewed in this paper. But our knowledge is still limited about other chemicals and the synergistic effects of POPs are still under scientific investigation. Even though many synthetic pesticides and organo-chlorine products have brought better things to life in terms of increased food production and availability, disease control, aesthetically appealing lawns and gardens, and other conveniences in everyday lives, paradoxically, these toxic chemicals are now frightening as they represent the very essence of dread in terms of the havoc they wreak on the environments, wildlife, and human health across the globe. Their ability to travel long distance to places they have never been produced or used begs international cooperation efforts to address these trans-boundary challenge.

Precautionary measures are required at every level, from

the individual to globally, to eliminate these elixirs of death and to find environmentally friendly substitutes. The Stockholm Convention on POPs may be considered the most significant international initiative designed to mitigate harm to human health and the environment from POPs and related chemicals. Thus, it represents a step in the right direction. Among the 12 POPs, DDT is the only one not completely banned, especially in the Third World, where its application to control malaria is paramount to any adverse health considerations. Despite remarkable achievements in reducing the production, distribution, and application of POPs, these toxic pollutants are now ubiquitous in the environment as evident by their presence in foods from around the world and in breast milk of nursing mothers (Schafer, Kegley and Patton 2001; Abelsohn et al. 2002). Even though all the 12 POPs have been banned or phased out in advanced industrial nations including the U.S., POPs residues in agricultural products from underdeveloped regions continue to represent a major pathway for human exposure.

Consistent with the cultural lag theory, thousands of toxic and hazardous chemical products are developed and released to the environment on a regular basis. Unfortunately, the laws designed to regulate these products are decades behind (Adeola 2002). Furthermore, funding for the development of innovative technologies that carry significant risk to health and the environment generally overwhelmed funding for research on understanding the magnitude, distribution, toxicity, and adverse impacts of chemical contamination (see Wargo 1996). Thus, reversing these previous trends are important aspects of arresting the risks posed by POPs and allied hazardous products. Rigorous scientific endeavors to develop safer, effective, and non-persistent substitutes and mitigation of adverse health effects of all POPs and chemicals with similar properties are strongly encouraged.

Endnotes

1. E-mail: fadeola@uno.edu
2. Othmar Zeidler first synthesized DDT in Strasbourg, Germany in 1874. In 1938, Edward Dodds announced the synthesis of DES and a Swiss chemist, Paul Muller also announced the insecticidal properties of DDT, hailed as a miracle which earned him a Nobel Prize for Physiology and Medicine in 1948. It was first used to control typhus from lice in 1942 and subsequently, the U.S. Department of Agriculture discovered it was an effective exterminator of numerous pests including mosquitoes, flies, fleas, and other insects.
3. See the UNEP website at www.chem.unep.ch/sc.
4. A comprehensive or exhaustive list of adverse health effects of POPs and allied toxic chemical compounds is beyond the scope of the present study.
5. A list of all other food items included in the FDA study is available online at: <http://vm.cfsan.fda.gov/~dms/pes99rep.html>.

6. For technical notes, methods, and list of food items, states in the U.S. and foreign countries sampled, see Tables 1, 2, and 6 of FDA's Total Diet Study at the site above.

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