Environmental Hazards and Health Impacts of Organochlorine Pesticides (OCPs) qua POPs in Benin's Cotton Basin

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Abstract- Organochlorine pesticides (OCPs) are carbon-based classes of chemical compounds classified as persistent organic pollutants (POPs) and produced for agricultural purposes. OCPs are used in the cotton-growing, which is now one of the mainstays of the appeal of these compounds in Benin, although their use was banned following the 2001 Stockholm Convention. In fact, the OCPs have raised problems such as contamination of the environment (soil, sediment, water, air and biota), hazards to organisms and also human health problems. Due to their solubility and persistence, they have been detected in foodstuffs, chains and food networks in Benin (vegetables, meat, milk, fish, crabs, amphibians, birds). Exposure to OCPs is associated with adverse effects in cotton producers, including headaches, dizziness, convulsions, loss of consciousness, blurred or dark vision, weakness, change in blood pressure, skin irritation, etc. Chronic effects related to pesticide exposure can lead to cancer, diabetes, reproductive disorders, Parkinson's disease and even death (e.g. endosulfan in Benin). OCPs are therefore well-known carcinogens, teratogens, endocrine disruptors, neurotoxins, etc. Although long-term/low-dose exposure to OCPs and POPs in general has long been suspected of causing adverse health effects, genetic and biochemical mechanisms underlying the effects of pesticides on these diseases remain to be elucidated in further studies.

Index Terms- Organochlorines Pesticides, Persistent Organic Pollutants, Cotton, environment, health, Benin.

I. INTRODUCTION

Organochlorine pesticides (OCPs) are a set of classes of synthetic compounds, ranked as POPs introduced as a result of technological and chemical revolutions leading to remarkable breakthroughs, but also caused an unexpected health issue. A common known OCP, dichlorodiphenyltrichloroethane (DDT) was applied in the period 1942-1960s as malaria control, typhus, and yellow fever diseases [1, 2]. However, their present harmful and serious adverse effects on the biosphere due to their physicochemical nature characterized by high lipophilicity, acute toxicity, persistence in environmental matrices (soils, sediment, air, and biota) classifying them as "long-range" [3-6].

Pesticides are chemicals used to impede, destroy, repel or reduce any harmful organism and are categorized as insecticides, rodenticides, herbicides, algaecides, fungicides or bactericides [7]. According to [8] just only 0.1% of applied pesticides achieve the targeted pests, while the remainder stays in their respective environment matrices through uptake, bio-accumulation and consequent bio-magnification along ecosystems and food chains [9-11]. Most pesticides are known fat-soluble and is able to easily accumulate within human tissues, maternal blood placenta, and breast milk [12-14] which have been described as good biomarkers of human exposure assessment to organic pollutants and reported in myriad studies across the world including Benin [15], China [16], Japan [17], Spain [18], Sweden [19], UK [20].

OCPs qua POPs due to their widespread applications are mainly found to be concentrated in high density populated of subtropical and tropical regions [21] where vulnerability factors such as extreme hot temperatures, galloping annual rainfall are prevalent [22]. Such areas are conducive to cash crops (e.g. cotton), which use invaluable amounts of OCPs. Unsustainable growing cotton i.e. with broad inputs of pesticides are responsible for large-scale ecosystem hazards and local living people's health and livelihood impairments.

Benin is, ranked among the leading cotton producers in Africa, where cotton-growing accounts for up to 75% of export revenues [23] and consumes 90% Beninese's insecticide market [24], compared to 24% world's insecticide market needed to that speculation [25, 26]. For very long some OCPs were broadly used in cotton pests control including DDT, lindane, endosulfan, heptachlor, endrin[27, 28]. Such products now have been banned from use at the Stockholm Convention in 2001 and in Benin.

The widespread use and application of OCPs qua POPs in Benin resulted in the nearly 37 cases of deaths during the 1999-2000 season and 5 deaths out of 105 cases between 2007 and 2008 due to the poisoning of Endosulfan in the Borgou region [29].

In North Benin, which records as the most cotton-growing area, high OCP concentration levels detected in aquatic ecosystems such as rivers of national parks, streams, and other surface waters supporting aquatic life [30]. Aquatic ecosystems are thus the final course of agricultural pesticides [31, 32]. For instance, DDT and dieldrin were detected at high levels in fish species of Oueme river (*Protopterus annectens, Schilbe intermedius, Clarias gariepinus*) [27, 30].

If recurrent cases of OCP residues are still detected despite their ban then there is a problem of their recent use likely in the growth of cotton in Benin. This current paper affords an overview of the

relationship between Organochlorine Pesticides used in the Beninese cotton-growing basin and their effects on the natural environmental matrices and human risks.

II. OCPs/POPs Legislation and Regulations

Pesticide remanence in food and cash crops has created a host of harmful effects on human and non-human organisms. Given the risks, it is urgent that measures are taken to prevent any further release about these hazardous compounds. Therefore, various international specialized institutions (Secretariat of Stockholm Convention, WHO, World Bank, FAO, UNEP, GEF, UNITAR), government (CCME, EPA) and non-governmental organizations (CIEL, IPEN, IFCS, PANNA), truly concerned by these contaminants, have consented considerable. POP production, use, and release, mostly organochlorine pesticides, implemented at the Stockholm Convention were banned or severely restricted in order to tackle POPs accumulation and biomagnification. From the abovementioned conventions, POPs were regulated and listed in Annex 1-4, [35].

Benin doesn't currently have a pesticide disposal infrastructure. However, the reduction and/or elimination of POPs pesticides is regulated by FAO guidelines and ratified conventions such as

- Stockholm Convention on POPs ratified in January 2004;
- Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, ratified on January 5, 2004. Under PIC, implemented jointly by FAO and the International Register of Potentially Toxic Chemicals (UNEP/IRPTC) in 1994, "*pesticides banned or severely restricted for health reasons or the environment are subject to the Prior Informed Consent procedure. No pesticide in these categories should be exported to an importing country participating in the PIC procedure contrary to that country's decision...*" [33]. For instance, endosulfan in Annex III of the Rotterdam Convention on PIC.
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, accession on December 14, 1997.
- -convention of Viennes, adhered on July 1, 1993, concerning the adjuvants present in the formulation of the molecules of pesticides

Through an investigation in Benin, it has been established a list of sixty-six phytopharmaceutical products whose importation and packaging for the national marketing as well as employment in agriculture are prohibited. From the sixty-six substances, seven of the twelve POPs revealed being listed in the Stockholm Convention. There are OCP such as DDT, heptachlor, dieldrin, aldrin, endrin, chlordane, and Mirex [34]. The review shows that the legislative framework for POPs is recent and is contained in the broader chemicals or poisonous substances. Benin is practically a country essentially consuming POPs that it imports. The lack of coherence of national policies on plant health protection, the sporadic or partial nature of agricultural control and the absence of pest risk analysis are some elements leading to ineffective implementation of the regulation, facilitating the informal. The informal pesticide distribution system has evolved very actively and has grown significantly due to the existence of a local service to the rural world, flexibility towards producers and the practice of costs. This circuit is this path that still encourages the use of OCPs and involves risks related to human, animal and environmental health.

III. OCPs Exposure Pathways

Through various routes, humans can be exposed to OCPs and hazardous substances including diet, occupation, accidents and both indoor and outdoor environments. These routes are easily assimilable to the breathing polluted air, dermal penetration or ingestion of contaminated foods and drinking water [2, 35]. Overall, exposure to pesticides can either be acute or chronic. In fact, acute exposure occurs obviously during pesticide production or chemical accidents [36]. For certain pesticides, point sources (e.g. WWTP) are responsible for high contamination compared to non-point sources. Symptoms of intoxication and exposure mode are closely bound, meaning chronic exposure occurs most commonly via dietary pathways [37]. For instance, chronic exposure recorded about the 12 banned POPs happened mostly through food products. Animal fatty tissues and edible oils especially from cottonseeds are major foods containing the greatest concentrations of pesticides. Food contamination by pesticides is one of worldwide concern [35] and chronic effects of prolonged exposure to pesticides may become important enough to cause clinical symptoms.

Therefore, Maximum Residue Limits (MRLs) is the legally and toxicologically acceptable maximum concentrations used to approve pesticide residues (in mg/kg) on or within foods and feeds [38, 39]. When residue value is higher than the MRL value then the residues are compared with the Acute Reference Dose (ARfD) and/or the Acceptable Daily Intake (ADI) [11, 40].

Survey programs across Benin territory have found pesticide residues in several agricultural products. Traces of organochlorines from DDT and derived groups, heptachlor lindane, dieldrin, and chlordane were reported in 17 fresh products, 7 stored commodities, and 116 plant product samples [41, 42]. Among the various contaminated agricultural products, yam chips, okra, cowpea, tomato were cited. In Benin's river flood plains, grown vegetables contained various concentrations of OCP, including DDTs (1,578 µg / g dw), drins (57 µg / g dw) and lindane (444 µg / g dw) which were above MRLs and safe consumption limits by WHO guidelines [2].

In addition, traces of these same pesticides have been identified in goat and cow's milk [41, 42]. The investigation of OCPs' bioaccumulation and exposure risks in Ivory Coast State reveals general contamination of cow's milk and butter by HCH (hexachlorocyclohexane), DDT and cycloidians groups [43]. The majority of pesticide pollutants introduced into the environment accumulate in livestock through fodder or contaminated water [44].

Water is involved in transporting pesticides from the field to surface or groundwater at the first rainy events after application with the 5% loss due to runoff. Pesticide fate depends on a relationship pesticide-soil property with meteorological conditions and site characteristics.

Pesticide residues identified in the different samples may, in the long term, because of their tendency to bioaccumulate, have toxic effects to varying degrees on the higher links of food chains (the problem of survival and reproduction). Contamination of water, plants, and insects (e.g. bees) involves the entire food chains. The man at the top of all food webs is not spared from this threat given his consumption of products contaminated by pesticides.

IV. OCPs Contamination of Natural Environment: Surface & Groundwater, Sediments and Soils

There is recorded evidence of OCP contamination in Benin water resources. Cotton pesticides are generally soluble in water, ranging between 0.3 and 1000 mg / L [45]. Rapid contamination of aquatic ecosystems by pesticides is facilitated via leaching, runoff, equipment washing, empty container disposal and the vicinity of crop growing field to water bodies. In Benin's cotton zone 46% of cotton and corn producers have a field within 500 m of water bodies or fish ponds. That means agricultural production facilities threaten aquatic life and the neighboring populations who make domestic use of these water bodies [46]. Recently, high concentrations of endosulfan (58–746 .g/L), DDT (6.45–100 g/L), dieldrin (1–48 .g/L) and heptachlor (34–83 .g/L) were detected in freshwaters (Fig.1) including Agbado (Savalou), Atacora, Djona, and W Park Rivers [27, 30] which by far exceed drinking water quality standards in Benin.

In addition, OCP residues including DDT and metabolites, Lindane, Endosulfan, and Aldrin and derivatives have been identified and quantified in sediments in Benin collected in Nokoué Lake [47], along the Ouémé River [48], Agbado River [49], Kiti river [50], Magou river [51], and at the Gogounou-Kandi-Banikoara cotton belt [28]. Sediments in some of these waters show DDT and metabolites residues high relative to detection limits and also compared to sediments in the subregions [30]. The high values of endosulfan reported in the Gogounou-Kandi-Banikoara cotton belt (120-150 mg/kg) were comparatively higher than some other streams. The high endosulfan presence may indicate recent use of this pesticide in cotton-growing regions through its reintroduction with the regional project on the prevention and management of worm cotton resistance *Helicoverpa armigera* [52].

In general, contaminated surface waters can sink to sediments. High values reported in certain sediments in Benin can be explained the belonging and proximity of the to the cotton fields, but also by the low solubility of OCPs settling on sediments when the streams are contaminated [30, 46].

The risks of soil contamination are all the greater as the products are intensively used and have high persistence in the soil. Pesticides joint soil during spraying or cleaning application equipment. These pesticides penetrate the soils where they undergo dispersion phenomena destroying mineral and organic elements and non-target organisms. The rest is infiltrating or draining towards streams.

V. OCPs Effects on Biota, Experimental Animals

Some examples of in vivo studies in human subjects or animal models and animal studies associated with human microbiota using a range of relevant pesticide concentrations were recently conducted.

Biota

Links have been established between POP pesticide exposure and fauna decline, disease or behavioral and congenital anomalies in fish, birds, and mammals, involving human health investigations. Wildlife populations could also be considered a sentinel for human health to sound the alarm bells [53]. Bird communities are a great terrestrial indicator of environmental pollution [44]. More commonly, fish show toxicological effects related to contaminant exposure, making them as well an adequate bioindicator in aquatic ecosystems [54, 55].

On certain adult birds in California, synthetic compounds cause acute mortality rate, sublethal stress, reproductive failure, elimination of egg formation, shell thinning, chick-rearing and behaviors hatching changes [56]. A study conducted in India reported that repetitive use of OCPs leads to a decline in birds' population like the bald eagle, sparrow hawk and peregrine falcon. Therefore, pesticides lead to habitat and population loss, behavioral changes and decline in several birds [57]. Moreover, pesticides act on wildlife endocrine system and disrupt the estrogen receptors (ER) or androgen receptors (AR). Most environmental chemicals are suspected to have anti-estrogenic effects [58] leading to a decrease in prolactin production [59].

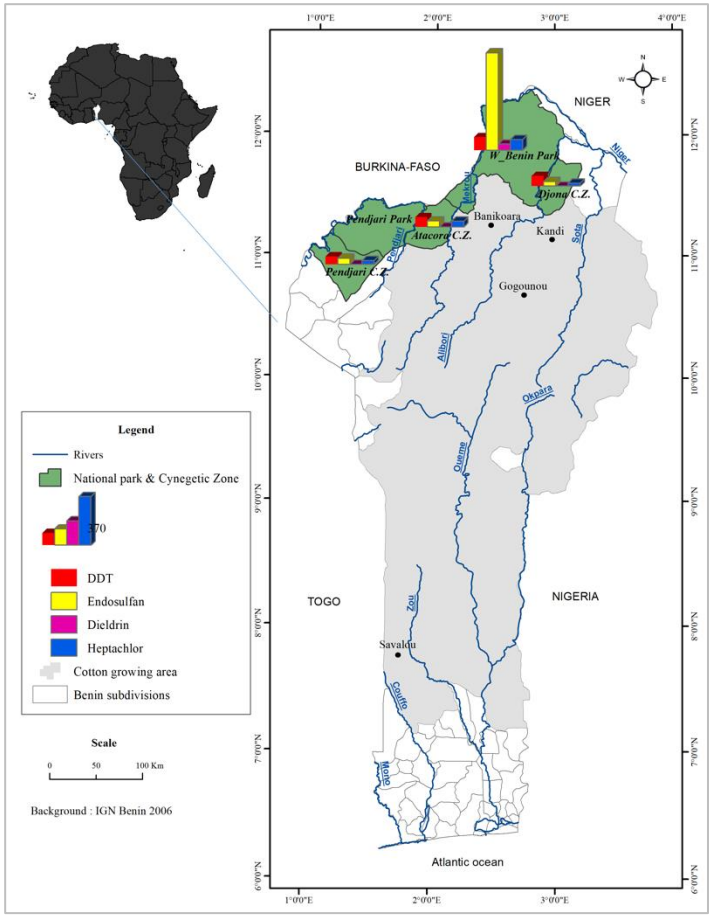

Fig. 1. OCPs occurrence in Benin
Data source: Adapted from [30]

In Benin, recurrent use of OCPs in cotton growing and in market gardening causes many fish species death including *Clarias gariepinus, Tilapia nilotica* and *Polypterus endlicheri*, observed in river systems and other Niger River tributaries [30, 51]. Such species of carnivorous fish, collected in various rivers located either internally or externally protected areas — Pendjari and W-Benin Park, flora and habitats — contain high concentration levels of DDT, DDE, Endosulfan, Lindane, heptachlor, dieldrin due to high lipophilicity, low water solubility and high persistence,

given them bioaccumulation and biomagnification capacity along the trophic chains [30]. In addition, lindane (105 µg / g), dieldrin (75 µg / g), heptachlor (30 µg / g), pp-TDE (28 µg / g) was reported in males *Sarotherodon melanotheron* within the Ouémé River [60] leading to health disruption of fishes due to the high lethal concentration. Recently, OCP residues collected in fish (*Clarias gariepinus*, *Clarias ebriensis*), amphibians (*Bufo regularis*, *Xenopus muelleri*) and crabs (*Cardiosoma aramatum*) in the Kiti River in Benin, were ranged between 23-515 ng / g lipid for ΣDDT and from 27- to 75 ng / g lipid for α-Endosulfan [50]. Contamination levels of residual Organochlorine compound collected were found highly greater to limit of detection fixed to 0.1 ng / g lipid due to cotton-growing activities in the area.

Overall, pesticide toxicity towards wildlife depends on the persistence and chemical degree toxicity. However, dose, time and duration of application are fundamental variables in a pesticide's toxicity. For example, Wildlife is more vulnerable to pesticide effects during nesting, breastfeeding, or in times of low food availability.

Experimental animals

The use of OCPs has resulted in persistent and widespread contamination of the natural environment, with effects on animal and human organisms. As a result, laboratory toxicity tests in animal models have been of inevitable use in assessing these effects, and even in detecting fatal cases.

For several years, fruit flies (*Drosophila melanogaster*) have been broadly used for environmental toxicology studies and elucidating human diseases. Therefore, it has been recommended as an alternative animal model for screening the risks caused by environmental chemicals in a study conducted by Sharma and collaborators [61]. Indeed, 0.02 to 2.0 µg /ml endosulfan concentrations exposed in the third instar fruitfly "Oregon R+" larvae diet has resulted in organismal responses such as a fly emergence delay with a remarkable decrease in adult flies' number and locomotor behaviors [61]. Moreover, chlordane exposure to zebrafish larvae (*Danio rerio*) have significantly a lower survival rate, developmental and hatching time delay and decreased embryo productivity. Such results indicated even chlordane at short-term exposure in daily-life acts as an endocrine-disrupting chemical and would result in changes in phenotypes and reproductive development [62]. A recent study has established the link between neurodegenerative risks in zebrafish and dietary exposure to dieldrin. Thus, dieldrin neurotoxicity is explained by the protein alteration related to the mitochondria, immune system, and Parkinson's disease [63]. exposure of heptachlor to mice resulted in movement deficits similar to parkinsonism and nerve dopaminergic neuronal loss [64]. Epidemiological investigations have revealed evidence of an obvious or almost no association with exposure to DDT and tumor development, or even cancer in humans. However, exposure to DDT demonstrated in rats and mice has induced obvious hepatho-carcinogenic tumors in the lungs, the liver and adrenal glands [65]. In addition, daily oral ingestion of 1.10 mg/kg lindane led to changes in gene expression in Rat Liver accounting for carcinogenicity. Recently, exposure of 1000 ug / L lindane to *D. melanogaster* is associated with tumor cell migration and changes in gene expression in Unfolded Protein Response (UPR) and Mitogen-Activated Protein Kinase signaling pathways (MAPK) [66]. Knowing that each type of organochlorine pesticide possesses intrinsic toxicity, it remains important to establish the molecular mechanisms underlying the adverse effects of environmental pollutants no matter they are pesticides, industrials products or disease control compounds.

VI. Organochlorine Pesticide (OCP) Exposure and Human Health Effects

A UN report published in 2017 said that although pesticide uses are well-correlated with food production increase, they had catastrophic effects on human health and the environment without ending hunger. it is counted every year, 200,000 individuals on average die as a result of exposure to toxic pesticides around the world [67]. Pesticide adverse effects associated with human health are related to the pesticide individual toxicity. Certain pesticides are nervous system disrupters. Others are the skin or eye irritants. Some are probably or possible carcinogens. And others may act as hormonal or endocrine system disrupting in the body. For instance, WHO states, "*Pesticide toxicity is dependent on its function and other factors. As a result, the herbicide compounds for humans are less toxic than the insecticidal ones*."[68]. OCP exposures at an acute, chronic or lethal dose are associated with diseases that can lead to death. Synergistic effects of pesticides are another phenomenon much less known and studied yet potentially even more dangerous. Also called "cocktail effect" and potentially devastating in the long term, health consequences of a mixture of different chemical pollutants remain severe. Thus, some of the pesticides found alone in water at given doses are considered non-hazardous, sadly the cumulative effects of many are largely unknown. Worse still, there are pesticides spread in natural waters to that point the number of their combinations at various concentrations is virtually impossible to simulate.

Endocrine system

OCPs are known as endocrine-disrupting chemicals (EDCs) since they interfere with the endocrine system function and normal molecular circuitry [44]. They are able to affect hormone signaling-like estrogen, thyroid and androgens, which are an essential part of normal embryonic development [69], mammalian reproduction and neurological function [70]. A study on prenatal exposure of Chinese pregnant mothers to DDT, HCB, b-BHC, and Mirex is associated with a significant birth weight decrease [71]. A similar study conducted previously on Ukrainian subjects showed a weight decrease for the highest levels of OCP exposure [72]. Spanish study revealed that certain OCP exposure to prenatal circumstances could impair the fetus anthropometric development, reduce 0.39 cm in birth length for each 10-unit increase in HCB concentrations, decrease 107 g, 63g, 53 g and 79 g in birth weight for each 10-unit increase respectively 4,4-DDE, 4,4'-DDT, b-BCH and HCB concentrations in cord serum, and head circumference of birth is reduced of 0.26 cm [73]. Certain researchers found a bonding between precocious puberty in females and pesticide exposures [74, 75] while others found their association with delayed puberty [76]. Indeed, a study of a group of participants from the Michigan Fishery Cohort revealed an increase of 15 ug / l in utero DDE exposure, reducing the age at menarche by 1 year [77]. Reduced gonadotropic hormones, delayed physical and sexual developments, delayed puberty and estradiol were associated with increased levels of OCPs in the blood of women living in South Kazakhstan cotton-growing regions [78]. It is

even obvious that precocious puberty mechanism is related to previous exposure to estrogenic endocrine disruptors like DDT in immigrants from developing countries to Belgium while native girls showed undetectable concentrations [74].

Neurotoxicity

Certain pesticides due to their toxicity are associated with neuron loss (neuronopathy), oxidative stress, cytoskeleton disruption, calcium overload, or mitochondria damaging, either by necrosis or apoptosis [79]. Lindane and some cycloidians including aldrin, chlordane, heptachlor, and dieldrin, have moderate to high acute oral toxicity with the central nervous system as their primary target [80].

The USA cohorts samples composed of ranchers, farmers and fishermen exposed to pesticides present a 70% higher incidence of Parkinson's disease (PD) [81]. In addition, several studies have recognized that occupational and chronic exposures to pesticides are a potential risk factor for various neurodegenerative diseases including madness and mild cognitive impairments, closely to Alzheimer's disease (AD) [82, 83]. In addition, several studies have recognized that occupational and chronic exposures to pesticides are a potential risk factor for various neurodegenerative diseases including madness and mild cognitive impairments, closely to Alzheimer's disease (AD) [84]. Similarly, in North India population, authors reported a significant association between AD and high levels of dieldrin (OR =2.086, 95% CI = 1.224-3.555) and β-HCH (OR = 2.064, 95% 95% = 1.373-3.102)[85].

It has been recognized that mitochondria have homeostatic functions in ion homeostasis, metabolic cell signaling, in the cell morphology regulation, mobility and multiplication, and in triggering apoptosis. Any events from environmental toxins (e.g. chlorinated cyclodiene: Dieldrin) that significantly alters ATP levels, the universal source of chemical energy in the cell, inhibit of biosynthetic pathways essential for mitochondrial function[86]. Recently, studies shown β-HCH and p'-DDE tend to accumulate in the liver resulting in mitochondrial dysfunction and changes in hepatic metabolite profile[87].

In children, OCP exposures are associated with neuron development problems recognizable by the reduction in mental and psychomotor functions [88], autism spectrum disorder (ASD) and Hyperactivity or not with Attention Deficit Disorder (ADHD) [89].

Carcinogenicity

Global cancer 2018 has reported 18.1 million new cases of cancer-related incidence and mortality. In fact, overall cancer cases, 11.6% of lung cancers, 11.6% of breast cancers, 7.1% of prostate cancers, 9.2% of colorectal cancers, 8, 2% of stomach cancers and 8.2% of liver cancers were diagnosed[90]. Moreover, organochlorine pesticides have been reported to increase the risk of hormone-related cancers, including breast, prostate, stomach and lung cancers [44]. The 1999-2004 National Health and Nutrition Examination Study in U.S. adults found a significant association between serum levels and the risk of prostate cancer prevalence[91]. In patients from southeastern Iran, the recording of higher serum levels of certain OCP (HCH, DDE, and DDT) is associated with colorectal cancer progression (CRC), the third most common cancer-caused worldwide death[92]. In addition, there is ample epidemiological evidence that exposure to endocrine-disrupting chemicals is associated with an increase in the incidence and prevalence of various human diseases, including breast cancer which is highly prevalent in the presence of p,p'-DDE [93]. Therefore, the human burden of carcinogens remains a concern of the world, especially when these cancer tumors migrate to neighboring tissues.

Recently, in the Borgou region, one of the leading departments of the Cotton growing area in Northern-Benin, the highest diabetes prevalence of 4.6% was recorded compared with the national average [94]. Thus, type 2 diabetes was associated with high DDT and other organochlorine pesticide concentrations in diabetic individuals. That means, despite DDT and 6 other OCPs are banned in Benin since 2004, they keep being provided by neighboring countries and national retailers for cotton pests, fishing and food preservation ends [15]. Beninese Organization for the Promotion of Organic Agriculture (OBEPAB) in 2016 conducted a survey with nearly 500 cotton farmers on aspects relating to pesticide use and its impact on human health. In fact, 17% reported signs and symptoms of acute pesticide intoxication more than six times in previous years, while 21% lost 2-5 days of work due to the effects of pesticide exposure [23]. Human health effects are caused by Skin contact (handling of pesticide products), Inhalation (breathing of dust or spray), Ingestion (pesticides consumed as a contaminant on/in food or in water) [33]. Several kinds of affection experienced after pesticide application in Benin were reported for this purpose Fig. 2.

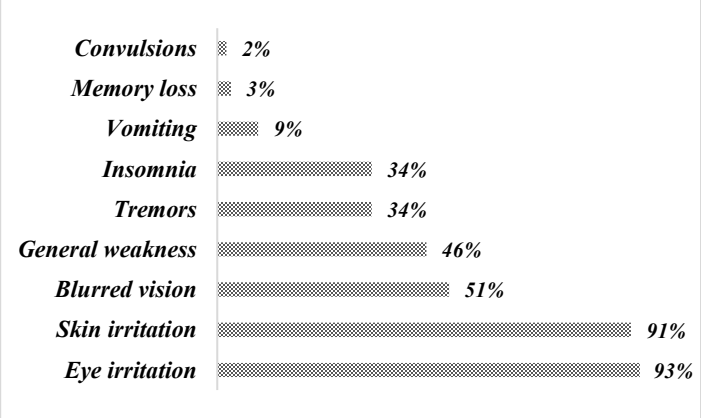

Fig. 2: Various Symptoms due to cotton pesticides reported by farmers in Benin
Data source: Adapted from [23]

VII. Climate Change and Pesticides Exposures

Overall, Global Climate Change (GCC) was predicted to increase the level of exposure to many environmental pollutants due to direct and indirect effects on the patterns of use, transport, and the fate of chemicals[95]. It might affect the different steps in the pathway from a chemical source in the environment through to an increase in vulnerability on human health.

Climate change including elevated carbon dioxide (CO_2) concentrations, changes in temperature and precipitation probably today increase the frequency and severity of pest outbreaks with high pesticide use, contamination, and concentration of POPs and heavy metals[96-98]. For instance, climate impact projections on Chinese origin pesticide usage will rise 0.5-1.2%, 1.1-2.5% by 2040, 2.4-9.1% by 2070, and 2.6-18.3% by 2100[99]. Changes in

temperature could act as co-stressors capable of affecting physiological processes in wildlife [69].

In fact, in aquatic species, lipid content is a key biological factor accounting for the concentration of POPs [100]. Within estuarine ecosystems, climate change resulting in variations in temperature and salinity, for example, could affect the susceptibility of marine organisms to pesticide contamination. In Florida, the toxicity DDT tested with Blue Crabs (*Callinectes sapidus*) revealed to be less toxic to these estuarine organisms at high temperatures [101]. Contrariwise, the toxicity of two common other pesticides in estuarine grass shrimp, *Palaemonetes pugio*, increased with temperature and salinity[102]. Therefore, Changes in climate stressors such as temperature and salinity may alter the toxicity of some pesticides and the nature of the effect will depend on both the organism, its stage of development, and the chemical contaminant.

Overall, the fate of pesticides is not sufficiently understood in tropical regions compared to temperate zones. But, the mechanism of tropical climates facilitates the rapid dissipation of pesticides involving increased volatility and improved chemical and microbial degradation [103].

VIII. Conclusion

There is growing evidence that organochlorine pesticides affect the natural environment and human health. Cotton cultivation in Benin uses a myriad of organochlorine pesticides that cause adverse effects. Despite recurrent cases of illness and death, there is virtually no link to the effects of pesticide exposure. As a result, toxicological data related to human health in Benin are almost non-existent. However, in order to reduce the environmental risk of organochlorine pesticides that cause disturbances to human health and biota, it is important to put in place certain strategies that are becoming increasingly important. These include (1) reducing the risk of pesticide transport through surface or ground water, (2) reducing the amount of pesticides used, and (3) reducing the persistence or mobility of active ingredients. It will also be necessary to develop best management practices (BMPs) that can reduce runoff, soil erosion or increase soil organic matter content, which will help to limit the transport of pesticides in the environment.

Abbreviations

FAO	: Food and Agriculture Organization of the United Nations
UNEP	: United Nations Environment Programme
GEF	: Global Environment Facility
UNITAR	: United Nations Institute for Training & Research
CCME	: Canadian Council of Ministers of the Environment
EPA	: U.S. Environmental Protection Agency
CIEL	: Center for International Environmental Law
IPEN	: International POPs Elimination Network
IFCS	: Intergovernmental Forum on Chemical Safety
PANNA	: Pesticide Action Network North America

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