

Review

Phytosanitary Practices, Regulations and Pesticide Poisoning in Africa: A Systematic Review

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Abstract: The inappropriate use of pesticides in the world and particularly in Africa, explains their presence in various environmental compartments. This presence in the environment has harmful consequences on living beings, especially humans.

This review, based on scientific publications, aims to analyze the problem of pesticides in Africa.

From a corpus of 81 articles published in Africa on this topic between 1996 and 2019, we have outlined the issues relating to phytosanitary practices, environmental pollution, food contamination, intoxication of farmers and consumers, qualitative and quantitative analysis methods used, as well as the regulations on the subject and their application in Africa. Based on an analysis of the factors that are at the root of the problems of environmental pollution, contamination and health that they cause in Africa, possible solutions were proposed to produce healthy products and preserve our common environmental heritage.

Keywords: pesticides; regulation; pollution; intoxication; qualitative and quantitative analysis

I. Introduction

The massive production and widespread use of plant protection products have made possible the intensification of agriculture with a spectacular increase in crop yields that contribute significantly to family incomes in Africa. In addition to their beneficial effects in crop protection, these pesticides have harmful effects on human and environmental health (1).

Thus, their use should only be allowed or encouraged if their methods of use and the risks to human health are perfectly mastered. Indeed, pesticides are used in excessive and inappropriate quantities in developing countries. This misuse is the cause of potentially harmful effects on human and animal health and on the environment.

It would be difficult to assess the effect of pesticides on the environment in Africa. It was not until the early 1990s that there was a real awareness of the need to protect the environment, leading to the creation of several non-governmental organizations concerned with the environment and its protection, and encouraging researchers to look into this subject. Studies are currently being conducted by educational and research institutions across Africa on the effect of pesticides on environmental components (water, soil, air, plants, food and feed, etc.). However, these studies are sporadic and still at an embryonic stage. Moreover, the number of researchers in this field is insufficient for a subject as vast and varied as this one. The absence of a specialized scientific journal bringing together all the research results makes access to information difficult, if not impossible.

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In view of the lack of statistical data from scientific studies giving a precise idea of the state of contamination of our environment by pesticides, an analysis of the problems inherent in this sector is necessary in order to properly define the pesticide-environment-health relationship in Africa. Globally, there is no monitoring of the environmental impacts of pesticides apart from what appears to be done episodically through academic studies, university theses, various environmental, agricultural and human health projects. Consequently, there is a lack of knowledge on the overall impact of pesticides on the environment as well as on human health (2).

In the light of these concerns, it seemed appropriate to undertake a review of the literature on pesticides in Africa: use, pollution and poisoning

The aim of this literature review is to produce a synthesis of recent publications on pesticides in Africa.

This review, based on scientific publications from the last two decades, aims specifically to evaluate the phytosanitary practices and knowledge of farmers in Africa, the application of regulations in this area, the level of pollution of ecosystems (soil, water and crop products) as well as the risks of exposure of populations, and to identify the different methods of analysis of the most commonly used pesticides in Africa.

In this literature review, the focus is on pesticides in the Democratic Republic of Congo, the country in which we are doing our thesis work on pesticides.

This document, which presents a review of the literature and existing actions on the issue of pesticides in Africa, will therefore follow up on our thesis work on "Phytosanitary practices, evaluation of the level of pollution of agricultural crops and risks of pesticide poisoning of consumers in the cities of Kinshasa and Lubumbashi in the Democratic Republic of Congo".

In this review, we will address the points on phytosanitary practices and pesticide use in Africa, pollution and pesticide poisoning, analysis methods and pesticide regulation in Africa. A brief analysis of the results of the articles used will be presented and the work will end with a general conclusion and recommendations.

2. Pesticides, Environment and Health in Africa

We will deal successively with the problems of pesticide poisoning, environmental pollution and food contamination throughout this first section.

2.1. Pesticide poisoning in Africa

In the absence of adequate monitoring systems and sufficient poison control centres, it is almost impossible to have official figures and reliable statistics on the number of cases of pesticide poisoning, accidents and deaths. However, a few examples from the literature provide some information on the situation.

We cite the results of a survey in the Niayes area of Senegal, which indicated that about 25% of market gardeners were most likely to have suffered from pesticide poisoning (3). The study on pesticide exposure and risk of type 2 diabetes in northern Benin reported that 4 organochlorines were found at serum concentrations above detectable limits in users (4). The article on the evaluation of biological indicators of exposure to organophosphate pesticides and the liver function of farmers in the commune of Gogounou in north-eastern Benin reports several cases of intoxication (5). In Morocco, although few studies have focused on the role of pesticides in toxic pathology, some of them have shown that they are a far from negligible cause of intoxication (6). Let us also mention the study on predictive factors of severity of pesticide intoxication by the Moroccan Poison Centre, which reported that mortality due to pesticides was 4.8%, with insecticides involved in 54.3% of cases followed by rodenticides (34%). Also in Morocco, a retrospective study of cases admitted to intensive care from 2003-2010 reported 28 cases of severe acute intoxication by organophosphate pesticides (7). On a national scale, according to data from the toxicovigilance unit of the Moroccan Poison Control Centre, 40487 cases of acute intoxication (excluding scorpion stings) were recorded between 1992 and 2003, 13.05% of which concerned acute pesticide intoxication (8). A retrospective study was carried out on 15 patients hospitalised in the medical intensive care unit of the Ibn Rochd hospital in

Casablanca for Phostoxin poisoning. (9). In another study it was demonstrated that there was a certain relationship between exposure to pesticides and the occurrence of hepatocellular carcinoma and, by ricochet, hepatitis. 17.1% of the subjects were diagnosed as positive for hepatitis B and C markers. And in the latter, a significant drop in the average post-exposure acetylcholinesterase level was noted compared to pre-exposure (10).

In Benin, in the study entitled "Toxicological effects and methods of analysis of lambda-cyhalothrin and acetamiprid used in the phytosanitary protection of cotton in Benin", the results show that lambda-cyhalothrin causes undesirable effects in humans such as diarrhoea, nausea, etc., while acetamiprid causes neurotoxic effects. Also in Benin, the results of a study on the estimation of the level of exposure of cotton growers show that they are highly exposed to phytosanitary products in the Benin cotton basin and that 85% of them felt unwell, with skin irritations, coughing, headaches, nausea and dizziness, explained by the harmful or toxic nature of the active substances used (11). The same ailments were reported by Toé in 2007, Gomgnimbou in 2009 and Son in 2017 among cotton and vegetable farmers in Burkina Faso (11). Another study carried out in Benin on food poisoning reported 347 cases of poisoning, including 53 cases of death from endosulfan, which is widely used for food preservation (12). The report of the investigation by Dr Gomez reveals cases of poisoning followed by deaths of 23 people who handled or consumed foodstuffs or groundnut seeds treated with Granox TBC or Spinox-T in the villages of the region of Kolda in Senegal between July and August 2000(13).

Endosulfan is incriminated in several cases of poisoning. 105 cases including 9 deaths due to this product were reported between May 2007 and July 2008. The annual number of pesticide poisonings in Mali is estimated at between 1,150 and 1,980 cases (14).

In the Democratic Republic of Congo, a study carried out in the city of Kinshasa revealed frequent symptoms of intoxication among farmers such as dizziness, nasal congestion, colds, red eyes, nausea and vomiting, etc. (15). The toxicology laboratory of the Faculty of Pharmaceutical Sciences of the University of Kinshasa recently recorded and followed up on a family in which 3 members showed signs of intoxication after consuming vegetables purchased from a market gardener. While no pathology had been diagnosed and consequently no action taken in the hospital where they had gone, the staff of the toxicology department of the Faculty of Pharmaceutical Sciences proposed an evacuating treatment which relieved the intoxicated persons after a few doses of a complexing antidote of the digestive tract, and their health condition was improved and restored. The article on this poisoning case is being published.

2.2. Environmental and food chain pollution by pesticides in Africa

A) Pollution of environmental matrices

Several studies reporting environmental pollution of surface water, groundwater and soils in very large quantities, leading to short and long term health problems in populations have been used in this review.

Among the articles reporting environmental contamination by organochlorine pesticides, we cite the article on the evaluation of pesticide contamination of the waters of the Couffo River in the cotton-growing area of Djidja in Benin (16). The article on Pesticides and the environment in Morocco reports contamination of groundwater, drinking water, soil and plants (17). The study of organochlorine pesticide residues in bivalves and fish from the Moulay Bousselham lagoon in Morocco showed significant contamination by organochlorine pesticides, with DDT and its metabolites present in significant concentrations in all species. (18). We can also cite the article on the pollution of the water table by pesticides in the Niaye area in Senegal. Analyses carried out on the wells in the area revealed the presence of pesticides in all the water samples collected, with very high cumulative average levels per well. Thirty-nine of the forty-five wells surveyed were contaminated by pesticide residues with concentrations above the World Health Organisation's standards (19). In the study on cotton production and water pollution by pesticides in Burkina Faso, the results show water pollution, particularly during periods of intense activity, with concentrations of endosulfan

and aldrin residues in the water of four villages in the major cotton production zone (20). At the Malika and Niaga sites in Senegal, dimethoate and endosulfan showed major contamination with respective average values varying between 0.011 and 0.035 mg/kg and 0.005 and 0.170 mg/kg (21).

As for organophosphates, we can cite the work carried out in the cotton production area of the Sikasso region, which reported the contamination of soil and well water. The results of this study reported that 29% of the pesticides used were from the organophosphate family with high environmental pollution (5). In the experiment on the evaluation of the contamination of drinking water, soil and sediments by heavy metals and pesticides related to cotton cultivation in the Gogounou cotton-growing area, the cyfluthrin content of pyrethroids was around 0.200 ppm in sediments and that of endosulfan and organophosphates around 0.080 ppm in all soils (22). Another example is the study on the evaluation of biological indicators of exposure to organophosphate pesticides and liver function in farmers in north-eastern Benin, in which the large-scale use of organophosphate pesticides is not without consequences for ecosystems (10).

B) Pesticide contamination of food

Among the works collected concerning pesticide residues in foodstuffs, some articles report quantities exceeding the limits set by the WHO. For example, the article on the control of organochlorine pesticides in milk and milk products reports the presence of organochlorine pesticides from the groups Dichlorodiphenyltrichloroethane (DDT), Hexachlorocyclohexane (HCH) and cyclodienes in the various samples at concentrations that are sometimes higher than those recommended by the FAO and WHO (23). Another paper in the same area of Sikasso found pesticide residues in market garden produce (24). The study on pesticide analyses in milk from the large dairy basins in southern Mali showed contamination by five organochlorine pesticides (25). Analyses of curdled milk and eggs in Côte d'Ivoire also determined their levels of contamination by organochlorine pesticides (26). In 2000, Djaneye and Boundjou detected organochlorine pesticide residues in varying concentrations in samples of vegetables grown in the market garden area of Lomé and in samples of cereals taken from various markets in Lomé, Ghana, Senegal and the Gambia in tubers, fruits and vegetables. Heptachlor was found in fish from Lake Nakuru in Kenya in 2004 (1). In Morocco, contamination of vegetables, fruits, mother's milk, cows and eggs is reported as a result of pesticide use (27). High levels of endosulfan, a highly toxic organochlorine insecticide whose use is prohibited, have been reported in 5 studies. For example, the article entitled: Food poisoning due to endosulfan: setting up a notification and management system, which reports the contamination of certain foods, including cereals and yam chips in Benin (23). In the article by firmzin on the analysis of water samples from the Couffo River it was revealed that four pesticides were present: glyphosate, profenofos, acetamiprid and cypermethrin. Even glyphosate was detected in all water samples at high levels, above the legal standard recommended for drinking water by the WHO (25). The study in Senegal reveals a worrying contamination of pesticides detected in food products sampled at suburban food markets (30). In the study entitled: Assay of organochlorine pesticide residues in row food samples from open markets in two African cities, the health risk assessment revealed that the number of organochlorine pesticides was above the required standards. (28)

3. Practice on the Use of Pesticides

A study conducted in Benin reports that the misuse of pesticides is at the origin of the numerous acute intoxications observed in developing countries in general and in Benin in particular (5). The article on the evaluation of environmental risk factors linked to the misuse of pesticides by market gardeners in Cameroon shows that despite the high level of education of farmers, the abandonment of pesticide remains in the open air and the incineration of empty packaging are the preferred methods of disposal (29). The study on farmers' phytosanitary practices in the savannahs of Central Africa indicates that farmers do not respect either the doses or the frequencies of pesticide application on crops. Indeed, market gardeners most often spray vegetables with a variety of insecticides and fungicides at inappropriate doses. And the doses applied vary from one producer to another. The majority of growers apply different doses until they reach the effective dose, and the number of

applications varies according to growers' experiences. For some, the treatment is done every time insects appear on the plant; for others, it is necessary to treat every three days without waiting for the appearance of insects. The doses of pesticides applied per treatment are generally higher than those recommended for any area or pesticide. The average doses applied in these areas are between 1.5 and 5 times those recommended (30). A study in Benin reveals that chemicals are abused and misused in most African countries and even that farmers often divert pesticides to uses other than those for which they were intended and use them without adequate safeguards because of high illiteracy rates (31). A survey in Senegal by Guèye found a positive correlation between the level of education of producers and unsafe pesticide use practices (32). In Morocco, intensive and unreasoned use of phytosanitary products is reported; doses and application dates are not respected (33). The article on the phytosanitary practices of market gardeners in southern Benin establishes a link between certain determinants, notably professional experience, age and poor phytosanitary practices (34).

In the Democratic Republic of Congo, although studies on pesticides are very rare, the study on the project to support the rehabilitation and revival of the agricultural sector notes that, on the whole, pesticides are not used according to safe standards due to several factors, including the lack of staff responsible for control, the limited resources available to these teams, the slow pace of behavioural change among users, etc. Several risky practices are therefore observed, notably the unprotected handling of dangerous products, the reuse of empty packaging for other uses, notably domestic. (35). Another study shows that market gardeners buy repackaged pesticides, sometimes in 100 ml bottles without labels. They know neither the specific pests to be controlled, nor the concentration and formulation of the product, nor the dose to be used, and do not protect themselves by wearing protective equipment during treatment (36). The study conducted in Central Kongo in the town of Nkolo indicates that market gardeners in Nkolo and its surroundings generally do not have a good knowledge of pesticides and do not follow the manufacturers' recommendations. And that the systematic application of pesticides is carried out without appropriate protective clothing and at high doses, thus putting them in regular contact with pesticides and exposing them to poisoning (37). Another study carried out at the University of Kinshasa's School of Health on the analysis of the knowledge, attitudes and practices of market gardeners in the city of Kinshasa in relation to the use of pesticides and the impact on human health and the environment indicates that the majority of market gardeners (94.9%) have not received any training on the use of phytosanitary products and do not have a good knowledge of the application doses and frequency of treatments (15).

4. Pesticide Regulation in Africa

The literature reports the existence of pesticide regulations in several African countries. The article on pesticides and the environment in Morocco indicates that any phytosanitary product, before being marketed in Morocco, is submitted by the producing or importing company, accompanied by a biological file, to the approval service of the Directorate of Plant Protection, Technical Control and Fraud Control. The latter carries out tests on the effectiveness of the proposed dose, its effects on insect pests and residues at plant level. Following these tests, and the results obtained, the product is registered or rejected (38).

Another article reports that Togo stopped the registration of most organochlorine pesticides in the 1970s to comply with the recommendations of the Food and Agriculture Organization of the United Nations (FAO) (1).

Among the large body of work collected, the West African Agricultural Productivity Programme, Pest and Pesticide Management Plan provides a description of the legislative and regulatory tools for pesticides in some African countries.

- In Cameroon, to ensure environmental protection, certain legal texts relating to pesticide management exist at the national level, for example law n° 2003/003 on phytosanitary protection.
- In Chad, law n° 14/PR/95 of 13 July 1995, relating to plant protection.
- In CAR: law n° 62/350 of 4 January 1963 regulates the circulation of plants, plant products and all other substances likely to carry organisms deemed dangerous for crops with regard to international texts and agreements: the three countries have signed the international Plant

Protection Convention (IPPC) and allowed the establishment in French equatorial Africa (FEA) of a plant protection organisation. All three countries have signed and ratified the Rotterdam Conventions on the Prior Informed Consent Procedure for certain products

- In Senegal: Pesticide regulation is based on law n°84-14 of February 2, 1984 relating to the control of agro-pharmaceutical specialities and similar specialities and decree n°84-503 of May 2, 1984 implementing the said law.
- In Burkina, Decree N°348-PRES-ECNA of 16/08/1961 instituting a phytosanitary control and regulating the conditions of import and export of plants, parts of plants, products of plant or animal origin and other materials entering or leaving the territory of the Republic of Upper Volta
- In Mali, the Constitution recognises "the right to a healthy environment" and stipulates in Article 15 that "the protection and defence of the environment and the promotion of the quality of life are a duty for all and for the State".
- In Ghana: The Environmental Protection Agency Act regulates the volumes, types, components and effects of waste or other sources of pollutants and/or substances that are hazardous or potentially hazardous to the quality of life, human health and the environment through the issuance of environmental permits and pollution abatement notices (39).
- In the Democratic Republic of Congo, Law No. 11/022 of 24 December 2011 on fundamental principles relating to agriculture is practically the only national text that comprehensively addresses the conditions for managing pesticides throughout the sector (import, storage, transport, use, disposal of containers, etc.). However, the application of this law is not yet in place. Any trader interested in the pesticide business undertakes it, even without a reception infrastructure and without prior technical knowledge for this type of trade (6).

5. Methods of Pesticide Analysis in Africa

Chromatographic methods are the most widely used for pesticide analysis in Africa. Gas chromatography has a superior performance for volatile and thermostable molecules and high performance liquid chromatography is suitable for polar, non-volatile and thermolabile substances. Of the twelve articles reviewed, we cite four in which gas chromatography coupled with a mass spectrometer was used, namely the study on the level of pesticide contamination of the waters of the Aghien and Potou lagoons in the south-east of Côte d'Ivoire (40), the study on cotton production and pesticide pollution of the waters of Burkina Faso (41), the article on the analysis of agricultural products and groundwater by pesticides carried out in the Niayes area in Senegal (42), the article on the analysis of pesticides and heavy metals in drinking water, soils and sediments in the cotton belt of Gogounou, Kandi and Banikoara in Benin (43). (Two other studies used the gas chromatograph with an electron capture detector (ECD), one on the determination of the residue content of five organochlorine pesticides in milk from the large dairy basins in southern Mali (44), and the other on the control of organochlorine pesticides in milk and dairy products (45).

Among the studies in which the liquid chromatograph was used are the study of peri-urban phytosanitary practices and pesticide contamination of foodstuffs: the case of market gardeners in Port-Bouët in Abidjan (43), the study on the level of pesticide contamination of peppers in Côte d'Ivoire (44), and the evaluation of the impact of antibiotics and pesticides used in livestock farming and agriculture on the sanitary quality of beef consumed in the North-East of Benin (44). We can also cite the study entitled: Contribution to the survey of the contamination of the market by the residues of pesticides (45).

In the literature, there are almost no other methods of pesticide analysis besides chromatographic methods in Africa. Among the few papers that have exploited other methods are "Sensitive electrochemical detection of methylparathion in the presence of para-nitrophenol on a glassy carbon electrode modified by functionalized NiAl-layered double hydroxide"(41) and "Synthesis and characterization of a composite by in situ polymerization of B-Cyclodextrin on smectite: Application to the electroanalysis of paraquat"(42) , in which electrochemical methods of pesticide analysis were exploited by Professor Ignace Tonle in Cameroon

6. Analysis of the Results of the Articles Studied

Pesticide poisoning is a reality in Africa, which remains the region where it causes the most problems. The World Health Organization estimates that there are one million severe pesticide poisonings worldwide each year, with some 220,000 deaths, of which about 99% occur in developing countries, even though these countries use only 25% of the pesticides produced in the world. Many socio-economic factors help explain this situation. In particular, the high illiteracy rate, the low economic level, the non-respect of good practices in the use of pesticides in general and the absence of personal protective equipment in particular, the lack of adequate storage facilities, the lack of training and information on handling rules which leads to an intensive and dangerous use of pesticides. This high number of deaths is also due to a lack of proper management of cases of intoxication linked to the inadequacy or even non-existence of specialized structures. Pesticide poisoning is a public health problem in many African countries, but unfortunately not well documented. In fact, statistics are not available in the health structures, which are poorly equipped to detect cases of poisoning. Furthermore, the lack of rigorous regulation and surveillance systems further aggravates the problem.

While in developed countries, plant protection products are subject to a rigorous approval process, African governments generally lack a strict regulatory framework for pesticide management and a monitoring system (fraudulent use of banned products, etc.). For example, endosulfan, which is now classified internationally as a persistent toxic substance, is still authorized for use in Africa (1).

As far as chemical analysis of pesticides is concerned, in Africa, and particularly in the Democratic Republic of Congo, there is a glaring lack of state-of-the-art equipment for analyzing phytosanitary products. Also, the high cost of analysis by advanced methods would prevent accessibility. It would therefore be important to develop routine pesticide analysis methods.

7. Conclusions

The literature review presented above aimed to examine the extensive literature on various aspects of pesticide management in Africa.

It highlighted the misuse of plant protection products in Africa due to the lack of training and information for producers as well as the non-respect of legal frameworks relating to the marketing and use of pesticides. This irrational use leads to problems of environmental pollution, contamination of drinking water and the presence of residues in crop products, most of which are banned from use because of the danger they pose. This situation is at the root of major problems of acute and chronic poisoning, thus aggravating the precarious health of the populations of Africa.

In order to reduce the risk of intoxication of African producers and consumers as well as environmental pollution, it is already urgent and important to promote the training of crop producers in the judicious use of pesticides in terms of frequency of use, quantities of active ingredients of chemical pesticides applied, etc. To sensitize producers on the risks inherent in the use of chemical pesticides (their direct and indirect consequences on health); to sensitize them to adopt hygienic measures during the spreading of pesticides, in particular by wearing individual protective equipment.

In the Democratic Republic of Congo, in view of the results of some studies that have been carried out there, it is equally necessary to know the level of pollution of the various environmental matrices by pesticides after their use and their impact on health.

References

1. Gbénonchi Mawussi, Bilan environnemental de l'utilisation des pesticides organochlorés dans les cultures de coton, café et cacao au Togo et recherche d'alternatives par l'évaluation du pouvoir insecticide d'extraits de plantes locales contre le scolyte du café (*Hypothenemus hampei ferrari*), Doctorat de l'Université de Toulouse, Décembre 2008.
2. Absdarman Traoré, Steven Mise en œuvre des politiques régionales sur les pesticides en Afrique de l'ouest : Rapport de l'étude de cas en Côte d'Ivoire, Food Security Policy Research, Côte d'Ivoire, working paper 67, August 2017.

3. Ibrahim Cissé, Abdoul Aziz, Tandia Safiétou, Touré Fall1 El Hadji, Salif Diop, Usage incontrôlé des pesticides en agriculture périurbaine : cas de la zone des Niayes au Sénégal, Cahiers Agricultures 2003, p3-617.
4. Baudouin WIKHA, Robert Nkumisongo, Les perspectives de la relance du développement agricole et de l'autosuffisance alimentaire de la RDC suite à l'adoption agricole en mai 2011), Kas African Law study Library1, 188-206,2015.
5. Dreyfuss, H. Lotfi Marquet Debord, JL. Daguet Lachatre, Analysis of pesticide residues in honey and apple by HPLC and GPC, Analusis 22(5) ,1994.
6. Naïma Rhalem, Asmae Khattabi, Sanae Achour, Abdelmjid Soulaymani2, Rachida Soulaymani Bencheikh, Predictive factors of severity of pesticide poisoning. Expérience du Centre Antipoison du Maroc, Annales de Toxicologie, Société Française de Toxicologie Analytique, France 2009.
7. Ali Derkaoui, Abderrahim Elbouazzaoui , Noufel Elhouari , Sanae Achour ,Smael Labib , Hicham Sbai , Mustapha Harrandou , Mohammed Khatouf, Nabil Kanjaa Severe acute intoxication by organophosphorus pesticides: about 28 cases ,Panafican medical journal , Casablanca,2011
8. Semlali I., Soulaymani R., Rapport d'activité de toxico vigilance du CAPM ,1992-2003.
9. Data from the Centre Antipoison et de Pharmacovigilance du Maroc (1992-2005), 1st national congress of the SMTCA, 10 and 11 March 2006 (abstract).
10. Benin Hinson, AntoineVikkey, Mama Cissé Ibrahim, Lawin Hervé, Dossou Fidèl, Gounongbé Fabien, Ayelo Paul, Evaluation of biological indicators of exposure to organophosphate pesticides and liver function of farmers in the commune of Gogounou in north-east Benin, Journal of the Society of Clinical Biology of Benin number 024,Benin ,2016, p9-14
11. Abdoul Ibrachi Gouda, Analyse des risques environnementaux liés aux pratiques phytosanitaires dans les écosystèmes aquatiques du bassin cotonnier (Nord Bénin), Thesis, Université de Liège, 2018
12. Intoxications alimentaires dues à l'endosulfan : mise en place d'un système de notification et de prise en charge au Bénin, environnement risque et santé, ERS, volume 8, N°2, Benin, 2009.
13. Mbaye Mbengue Faye, Plan de gestion des pestes et des pesticides, Agence Régionale de Développement de la Région de Ziguinchor, Projet du Pôle de Développement de la Casamance (PPDC), République du Sénégal, May 2013
14. Soliou Badarou, Yves Coppieters, Intoxications alimentaires dues à l'endosulfan : mise en place d'un système de notification et de prise en charge au Bénin. Tchaourou health zone, Université Libre-de-Bruxelles, Environnement risques santé, ERS, 2009
15. Georgette Ngweme Ngakiam, Guillaume Kiyombo MBELA , Céline Sikulisimwa Pole, Crispin Mulaji Kyela , Jules Aloni Komanda, Analyse des connaissances, attitudes et pratiques des maraîchers de la Ville de Kinshasa en rapport avec l'utilisation des pesticides et l'impact sur la santé humaine et sur l'environnement Ecole de Santé Publique, Faculté de Médecine ,Université de Kinshasa, Afrique Science 15(4) ,2019 .
16. Firmin H., Aïkpo Christophe, B.Chabi, Virgile Ayi, Luc Koumolou, Christophe S. Houssou, Patrick A. Etorh, Evaluation of the contamination of the waters of the Couffo River in the cotton zone of Djidja (Benin) by pesticides, International Journal of Biological and Chemical Sciences 9(3)1725-1732, 2015.
17. Mait el cadi, A. mezzane, B. meddah, Y. khabbal, L. idrissi, fatal pesticide intoxications in Morocco (2000-2005), journal of epidemiology and public health 57, s6,2009
18. Moulay Boussehham, Benbakhta Bouchaib, Fekhaoui Mohamed, El Abidi Abdellah, Idrissi Larbi, Organochlorine pesticide residues in bivalves and fish in the lagoon, Morocco. Afrique Science 03(1) 146 - 168 ,2007.
19. S. Ngom et al , Contamination of agricultural products and groundwater by pesticides in the Niayes area of Senegal, UBMA ,2012
20. Hermann K. Tapsoba, Yvonne Bonzi-Coulibaly, Production cotonnière et pollution des eaux par les pesticides au Burkina Faso, J. Soc. Ouest-Afr. Chim. 21; 87-93 2006
21. Saliou Ngom1, Traore Seydou, Mamadou Bocar Thiam, Manga Anastasie, Contamination of agricultural products and groundwater by pesticides in the Niayes area of Senegal, Revue de Sciences et Technologies², Synthèse 25: 119- 130, Senegal, 2012
22. Adam, Patrick A., Etorah, Henri Ttin 3, Pesticides and heavy metals in drinking water, soils and sediments of the cotton belt of Gogounou, Kandi and Banikoara (Benin) Soulé, International Journal of Biological and Chemical Sciences,vol 4,2010 .

23. Naïma Rhalem, Asmae Khattabi, Sanae Achour, Abdelmjid Soulaymani², Rachida Soulaymani Bencheikh, Predictive factors of severity of pesticide poisoning. Expérience du Centre Antipoison du Maroc, Annales de Toxicologie, Société Française de Toxicologie Analytique, France 2009.
24. Omar Ben Khatab Ndiaye, Technologies de décontamination de sols contaminés par des pesticides au Mali, Centre universitaire de formation en environnement Université De Sherbrooke, Sherbrooke, Québec, Canada, May 2010
25. Boubacar Madio, Aladiogo Maïgai, Ibrahima Koné, Oumou Haïdarai, Salimata Koné, Détermination de la teneur en résidus de cinq pesticides organochlorés dans le lait des grands bassins laitiers au Mali-Sud Journal of Biological Chemistry Sciences.12(6) :2680-2690, 2018
26. D. L Kouadio, SGA ehouman, BD. Soro, M. Diarra, Contamination of curdled milk and egg consumed in Côte d'Ivoire by organochlorine pesticides, International Journal of Science and Technology 10(4) ,2014, p61-69
27. F. Zine Elabidine, Les pesticides et environnement au Maroc Inra, Département de génétique appliquée, Al awania 92, Rabat, Morocco, March 1996.
28. Moulay Bousselham, Benbakhta Bouchaib, Fekhaoui Mohamed, El Abidi Abdellah, Idrissi Larbi, Residus de pesticides organochlorés chez les bivalves et les poissons de la lagune, Maroc. Afrique Science 03(1) 146 - 168 ,2007.
29. Dreyfuss, H. Lotfi Marquet Debord, JL. Daguet Lachatre, Analysis of pesticide residues in honey and apple by HPLC and GPC, Analusis 22(5) ,1994.
30. S.P.Sougnabe, A .Yanda, J .Acheleke, T .Brevault Pratiques phytosanitaires paysannes dans les savanes d'Afrique centrale, Savanes Africaine en développement, 2010
31. Byassogba Komlan, Anihouvi Prudent, Achigan Enoch, Sikirou Rachidatou, Boko Adrien, Adj. Charlotte, Ahle Victoire, Pratiques culturales et teneur en éléments anti nutritionnels (nitrates et pesticides) du Solanum macrocarpum au sud du Bénin, African journal of food, agriculture, nutrition and development 7(4)1-21 ,2007
32. Guèye-Girardet, Evaluation of irrigation, fertilisation and pesticide application practices in peri-urban agriculture in Dakar, Senegal, Serveral ,2010
33. F. Zine Elabidine, Les pesticides et environnement au Maroc Inra, Département de génétique appliquée, Al awania 92, Rabat, Maroc, Mars 1996
34. Benin Claude Ahouangninou , Setondji Yacin, Wilfrid Boko , John Logbo , Françoise Assogba Komlan ,Thibaud Martin ,Benjamin Fayomi , Analysis of the determinants of phytosanitary practices of market garden producers in the south of ,Africa Science 15(5), 2019
35. Study on the Support Project for the Rehabilitation and Revival of the Agricultural Sector (PARRSSA)Pest Management Plan (PGP), final report, Ministry of Agriculture, Fisheries and Livestock, Democratic Republic of Congo, November 2016
36. M.Hayo G.van der Werf, Evaluer l'impact des pesticides sur l'environnement, de l'environnement de l'INRA n° 31, Colmar, 1997
37. Tony M. Muliele, Constantine M. Manzenza, Léon W. Ekuke, Cécile P. Diaka, Dieudonné M. Ndikubwayo, Olivier M. Kapalay, Aimé N. Mundele, Pesticide use and management in market gardening: the case of the Nkolo area in Central Kongo province, Democratic Republic of Congo, Journal of Applied Biosciences 119: 11954-11972 November 2017
38. Moulay Bousselham, Benbakhta Bouchaib, Fekhaoui Mohamed, El Abidi Abdellah, Idrissi Larbi, Organochlorine pesticide residues in bivalves and fishes of the lagoon, Morocco. Afrique Science 03(1) 146 - 168 ,2007.
39. Djibril Doucouré, Report of the West and Central African Council for Agricultural Research and Development (CORAF) West Africa Agricultural Productivity Programme, Pest and Pesticide Management Plan, January 2007
40. Projet de Réduction du Risque de Famine et de l'Amélioration de la Nutrition dans la Région du Kasai (PRRF), final report, May 2018.
41. Hermann K., Tapsoba, Yvonne,L.Bonzi, Coulibaly Boubacar,Madio Aladiogo maïga, Ibrahima Koné, Oumou Haïdara, Salimata Koné, Fousseni Diallo, Alimata Berthe, La production cotonnière et pollution des eaux par les pesticides au Burkina Faso Société Ouest-Afrique de Chimie 21, 87-93 ,Burkina Faso ,2006
42. Diarra Moussa and Kouadion David Niveau de contamination du poivron (Capsicum L., 1753) par les pesticides à Abidjan, europeanscientific Journal, 2018, Vol 14 n.6.

43. Abidjanguins Kouakou, Aho Lazarre, Chantal Assoh, Roland Kossonou, Des pratiques phytosanitaires périurbaine et contamination des denrées par les pesticides : cas des maraîchers de Port-Bouët, journal of Animal and plant, Vol 41,2019 Abidjan
44. Sémanou Robert Dorgon, Evaluation of the impact of antibiotics and pesticides used in animal husbandry and agriculture on the sanitary quality of beef consumed in the North-East of Benin, University of Liege Belgium, PhD thesis, 2018
45. Ignace Tonle, Sensitive electrochemical detection of methylparathion in the presence of para-nitrophenol on a glassy carbon electrode modified by functionalized ni-ai-layered double hydroxide, University of Dshang, Cameroon, December 2018
46. Ignace Tonle, Synthesis and characterization of a composite by in situ polymerization of B-Cyclodextrin on a smectite: application to paraquat electroanalysis, University of Dshang, Cameroon,2017
47. Karim Traore et al, Regulatory framework for pesticides in South Africa, 548X. africa Science 04(1) ,2008
48. G.van der Werf, Evaluer l'impact des pesticides sur l'environnement, courrier de l'environnement de l'INRA n° 31, Colmar, 1997
49. Djibril Doucouré, Report of the West and Central African Council for Agricultural Research and Development (CORAF) West African Agricultural Productivity Programme, pest and pesticide management plan, January 2007
50. Tarla1, F. Meutchieye, V. A. Assako1, D. A. Fontem, J. J. A. Kome, Exposure of market gardeners during pesticide application in the western highlands of Cameroon Journal of Agricultural Science Vol. 3(5), pp. 172-177, 2013
51. Onil Samuel, Louis St-Laurent, Denise Phaneuf, Stéphane Buteau, Marie-Hélène Bourgault, Mesures de réduction de l'exposition aux pesticides dans les aliments, Institut national de santé publique de Québec, September 2010, p9-11.
52. Benin Hinson, AntoineVikkey, Mama Cissé Ibrahim, Lawin Hervé, Dossou Fidèle, Gounongbé Fabien, Ayelo Paul, Evaluation of biological indicators of exposure to organophosphate pesticides and liver function of farmers in the commune of Gogounou in northeastern Benin, Journal de la Société de Biologie Clinique du Bénin number 024,Benin ,2016, p9-14
53. Dhib ahlèm, validation of a method of analysis of pesticides in fresh tomatoes by gas chromatography associated with liquid scintillation counting ,2011
54. Camille Le Jean, René Dumont revisited and African agricultural policies, Collection débat et controverse numéro 9, Paris, January 2014
55. Eglin Thomas and Colomb Vincent, Emissions au champ de pesticides vers l'air en conditions tropicales, IRSTEA N° 14-60-C0083, May 2016.
56. Ousmane Z. Traoré1 , Lota D., Tamini, Effet des Limites Maximales de Résidues de Pesticides imposées par les pays de l'OCDE sur les Exportations des pays Africains - Exemple des Mangues, Centre d'étude pluridisciplinaire en commerces et investissements de commerce internationaux, Mars 2019
57. Abdoul Ibrachi Gouda, Analyse des risques environnementaux liés aux pratiques phytosanitaires dans les écosystèmes aquatiques du bassin cotonnier (Nord Bénin), Thesis, Université de Liège, 2018
58. Hermann K. Tapsoba, Yvonne Bonzi-Coulibaly, Production cotonnière et pollution des eaux par les pesticides au Burkina Faso, J. Soc. Ouest-Afr. Chim. 21; 87-93 2006
59. Saliou Ngom1, Traore Seydou, Mamadou Bocar Thiam, Manga Anastasie, Contamination of agricultural products and groundwater by pesticides in the Niayes area of Senegal, Revue de Sciences et Technologies², Synthèse 25: 119- 130, Senegal, 2012
60. Mbaye Mbengue Faye, Plan de gestion des pestes et des pesticides, Agence Régionale de Développement de la Région de Ziguinchor, Projet du Pôle de Développement de la Casamance (PPDC), République du Sénégal, May 2013
61. Semlali I., Soulaymani R., Rapport d'activité de toxico vigilance du CAPM ,1992-2003.
62. Celie M., David JG., van der Hoek W, Dawson A, Wijeratne IK, Konradsen F. Self-poisoning in rural Sri Lanka: Smallarea variations in incidence. BMC Public Health 20 8 : 26,2008.
63. Data from the Centre Antipoison et de Pharmacovigilance du Maroc (1992-2005), 1st National Congress of the SMTCA, 10 and 11 March 2006 (abstract).
64. Soliou Badarou, Yves Coppieters, Intoxications alimentaires dues à l'endosulfan : mise en place d'un système de notification et de prise en charge au Bénin. Tchaourou health zone, Université Libre-de-Bruxelles, Environnement risques santé, ERS, 2009

65. S. Sougnabe, A.Yandia, J. Acheleke, Pratiques phytosanitaires paysannes dans les savanes d'Afrique centrale, Institut tchadien de recherche agricole pour le développement, ITRAD, 2009.
66. Communauté Economique et Monétaire de l'Afrique Centrale (CEMAC), Regulation No. 09 adopting common regulations on the registration of pesticides in the CEMAC region, 2006, P2 .
67. M. Demaimay, G. Lavoue, M. Feuillat, J. P. Pierrot, essai de dosage qualitatif et quantitatif de quelques pesticides organochlorés dans les produits laitiers par l'utilisation d'une pré colonne en chromatographie gaz-liquide, 1972
68. Programme d'investissement pour le foret (pif) plan de gestion des pestes et pesticides (pgpp) en République Démocratique du Congo, April 2014, projet de gestion améliorée des paysages forestiers (pgapf)
69. Khadîdja el Mrabet, development of a method of analysis of pesticides by isotopic dilution associated with liquid chromatography coupled with tandem mass spectrometry in cereal matrices after extraction in pressurised hot solvent, thesis pierre et marie curry university.
70. Raoul Calvet, Les pesticides dans le sol : Conséquences agronomiques et environnementales, France Agricole Editions, 2005
71. Dulaurent, Mise en place d'outils d'aide au traitement de demandes de dosage de pesticides dans les milieux biologiques, Limoges ,2018.
72. European Union policy and legislation on pesticides, European Parliament 2017
73. Bernard Capolaghi, Moustapha Moulsmann, Nicole Houdret, Frédéric J Baud, Stratégies analytiques en Toxicologie d'urgence, Annales de toxicologie Analytique 12,2006.
74. Naima Rhalem, Asmae Khattabi, Sanae Achour, Abdelmid Soulavmani, Rachida Soulavmani, Factors predictive of severity of pesticide intoxication Experience of the Moroccan Poison Control Centre, Annals of Analytical Toxicology 21(2) ,79-84,2009
75. Martin P Aina, Prudencio Agbohessi, Ibrahim Imorou Toko, Marie-Louise scippo, International journal of Biological and chemical Sciences 9 ,20156.
76. Mohamed Benzine, Pesticides: Toxicity, residues and analysis, Laboratory technologies 1 ,2006
77. A. Srun Bennani la phytopharmacie, son rôle et ses fonctions contribution a l'organisation du laboratoire de phytopharmacie au Maroc ,2019.
78. Jean de Dieu Minengu Mayulu, Etude des possibilités de cultures de Jatropha curcas dans la ville de Kinshasa (République Démocratique du Congo), Gembloux agro-bio Tech, p2014. 25. Jean-Baptiste Baugros, Research and development in the field of biofuels.
79. J. Goursaud, f. M. Luquet, j. Casalis, Rapid method for monitoring the residue content of some organochlorine pesticides in hal dairy products
80. International ethical guidelines for health research involving human participants, CIOM, 216, p13-17
81. Bayili Bazoma, Environmental risks related to the use of pesticides in two agro-ecosystems based on conventional and organic cotton at Komplan 2 in the commune of Dano in Burkina Faso, Programme Coton, INERA, Burkinafaso,2014, p10-14