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Chemical family of pesticides used in market gardening around the Kalsom dam in the Didagou watershed area (Dapaong, northern-Togo)

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Abstract: The Kalsom dam in the Didagou watershed (Dapaong, Togo) due to its assets is used for market gardening with intensive use of chemical agricultural inputs. This misuse of pesticides on vegetables is a potential source of contamination for consumers and the environment. The present study aims to make an inventory of the pesticides used around this dam. A survey by individual semi-structured interviews was carried out with fifteen (15) responsible market gardeners. The questionnaire focused on the pesticides used, the pesticide packaging management method and the characteristics of market gardeners. The results showed that the market gardeners surveyed, all men, use a variety of pesticides, mainly formulations of the emulsifiable concentrate type for 77.78% of the formulations listed. They are grouped into eleven (11) active ingredients and eight (08) chemical families in which Pyrethroids are more represented with a frequency of 35.71% followed by neonicotinoids (14.29% of cases). These pesticides were used on five (05) vegetable species, namely: *Beta vulgaris* L., *Daucus carota* L., *Brassica oleracea* Var. capitata, *Alium cepa* L. and *Capsicum annuum* L. After the use of pesticides, the use or method of disposal of empty packaging is worrying. It is contrary to that recommended by the provisions of the FAO code, thus constituting a danger for people but also for animals which often graze the grass in the fields after harvest. The level of education of market gardeners does not allow them to adopt exemplary behaviors to avoid health and environmental risks.

1. Introduction

The rapid increase in the world population and that of developing countries poses several problems, including that of food security (PNUE/FAO, 2005). In Togo, the development of market gardening constitutes a tentative remedy for the supply of fresh vegetables to the populations of the cities and by resolving the problems of unemployment, underemployment of young people one the one hand, and on the other hand that of poverty, rural exodus even misery (Mondedji *et al*., 2015). Several vegetables are grown there; 43 market garden species divided into 30 genera and 17 families in Togo have been identified (Kanda *et al*., 2014). Faced with the growing demand for fresh vegetables, producers are looking for ways and means to increase their production and improve their financial

income. To achieve this, they use, among other things, phytosanitary products commonly called pesticides (Theriault *et al*., 2021; Ben salem *et al*., 2014;). In Dapaong (as in other towns in the country), because of the high cost of pesticides specific to market gardening, producers living near the Kalsom dam are forced to buy synthetic pesticides not recommended for these crops in the street or in neighboring countries (Burkina-Faso, Ghana) (Etse *et al*., 2014). The problem is compounded by aggressive sales strategies, when retail sellers target market gardeners who can barely read and write to sell them crop protection products of dubious quality (Houngnihin *et al*, 2021; Ohui, 2014). In doing so, the residues of these pesticides inevitably constitute short, medium or long-term poisoning risks for humans through contamination of the food chain (Theriault *et al*., 2020; Ahoudi *et al*., 2018). Moreover, these pesticides constitute sources of pollution for the environment (Marlett *et al*., 2022; Zerouali *et al*., 2006), particularly through their accumulation in the soil (Pelosi *et al*., 2021), in surface water (Montiel *et al*., 2019) and in groundwater (Adam *et al*., 2010). The World Health Organization (WHO) estimates that 385 millions of people are poisoned each year by chemical pesticides, including about 11,000 fatalities (Boedeker *et al*., 2020).

While it is true that phytosanitary products are an effective means of protecting crops and reducing damage caused by pests to crops intended for human consumption (PAN, 2019), the uncontrolled use of pesticides can have harmful effects on the biological diversity and increase the resistance of target organisms (Haubruge and Amichot, 1998; Sabbahi *et al.* 2022). This consequence leads to the use of increasing quantities. In developing countries, we are witnessing an excessive and inappropriate use of pesticides, but also failure to respect the time limits for the persistence of phytosanitary products before harvesting (PAN-Africa, 2000; Theriault *et al*., 2021; El Ouadi *et al.* 2017). Although the supply and demand for market gardening products are growing, statistical data on the market gardening sector, including the use of pesticides, is almost non-existent.

The purpose of this study is to make an inventory of the use of pesticides by market gardeners in the Didagou watershed (around the Kalsom dam) in order to know the chemical families of pesticide residues to be evaluated in the food products and in the ecosystem of the Kalsom dam.

2. Materials and methods

2.1 Study area

The commune of Dapaong is part of the prefecture of Tone (extreme north of Togo) in the savannah region. With an area of 115 km2, it is located at 650 km from Lome, the capital town of Togo, and 300 km from Ouagadougou, the capital of Burkina Faso. It has a tropical Sudanese climate with a long dry season which strongly handicaps agriculture. The temperatures there are very high, sometimes exceeding 42°C and the cumulative annual rainfall varies between 900 to 1200 mm (Lare, 2012).

In 2016, the population of Dapaong was estimated at 64 800 inhabitants and will reach 85 400 inhabitants by 2030 (DGSCN, 2011). This population, although urban, practices a lot of agriculture as the main occupation. The Didagou backwater concentrates the runoff from Mount Monefiago, crosses the center of the city from south to north to flow with all its pollutant load into the Kalsom dam. Located between 10°48'59.0" and 10°51'44.3" North latitude and between 0°09'36.7" and 0°10'23.2" East longitude, this dam is 7 km south- West of the commune of Dapaong, on the Didagou river. With a perimeter of 12 815 m, it covers an area of 286.04 ha and extends over approximately 8 km. Market gardening with the intensive use of chemical fertilizers and pesticides constitutes a regular practice around this dam

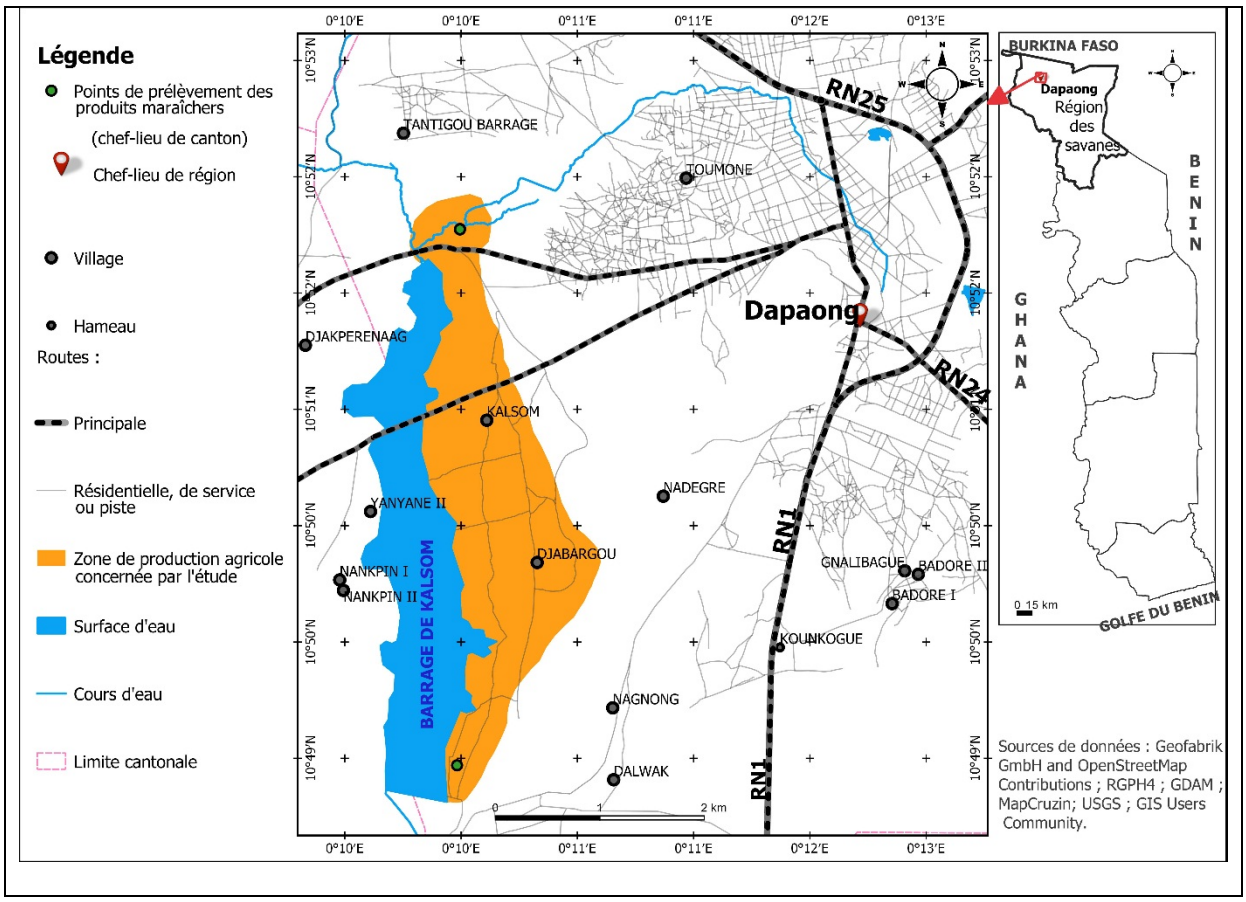

Figure 1. Map of Dapaong town showing the Kalsom dam and the market gardening sites surveyed

2.2 Methodology

The methodological approach adopted is participatory. A survey by individual semi-structured interviews was carried out in January 2019 with market gardeners living near the Kalsom dam in the Didagou watershed area. The questionnaire focused on the pesticides used, the pesticide packaging management method and the characteristics of the market gardeners (name, sex, age, level of education, etc.). For some aspects of the research I focused on factual observation. The sampling involved group leading market gardeners residing in the villages of Tantigou-Kpadongue, Kalsom and Djabargou. A total of fifteen (15) market gardeners organized around five (05) per village were interviewed. It should be noted that only five (05) market gardeners responsibles from the village of Kalsom were present at their workplace on the day of the survey.

The first part of the work consisted in carrying out an inventory data of the various pesticides used in market gardening around the Kalsom dam (the photos of the packaging were taken for the subsequent identification of the chemical families). The determination of active ingredients, chemical families was made using established and recognized phytosanitary indexes (Dubois, 1985), (Couteux et Lejeune, 2003).

A sample of market gardening species (on which pesticides were applied) grown and eaten in the Didagou catchment area was taken during the survey. The plant products (ready to be eaten at this time) sampled (**Table 1**) are photographed and placed in labeled plastic bags. They are then put in a cooler containing ice (about 4°C) and are transported to the laboratory. The identification of the species of market garden products sampled (**Table 1**) was carried out at the Laboratory of Botany and Plant Ecology of the University of Lomé.

Table 1. Different market gardening species grown around the Kalsom dam encountered during the surveys

N°	Common name	Edible part removed	Species	Familly
1	Beetroot	Tuber	*Beta vulgaris* L.	Chenopodiaceae
2	Carott	Tuber	*Daucus carota* L.	Umbelliferae
3	Cabbage	Leaf	*Brassica oleracea* Var. capitata	Brassicaceae
4	Onion	Bulb	*Alium cepa* L.	Alliaceae
5	Chilli pepper	Fruit	*Capsicum annuum* L.	Solanaceae

3. Results and Discussion

3.1 Pesticides used by market gardeners

Market gardening is highly developed in the Didagou catchment area (near the Didagou backwater and especially on the banks of the Kalsom dam (**Figure 2**) in the peri-urban area of the Dapaong commune. Market gardeners use various phytosanitary products to improve their yield.

Figure 2. Market gardening around the Kalsom dam

The inventory of pesticides used regularly by the populations living near the Kalsom dam in the Didagou watershed is recorded in **Table 2**.

Table 2. Inventory of pesticides (insecticides) used in market gardening around the Kalsom dam

Trade name	Active ingredient	Chemical Familly	Formulation
Deltaplus (Plan D)	Deltamethrin 25g/L	Pyrethroid	EC
Deltapyr 84 EC	Deltametrhrin 24 g/L + Pyriproxyfen 60 g/L	Pyrethroid + Pyriproxyfen	EC
EMIR FORT 104 EC	Acetamiprid 72 g/L + Cypermethrin 32 g/L	Neonicotinoid + Pyrethroid	EC
K-optimal	Lambda-cyalotrin 15g/L + Acetamiprid 20g/L	Pyrethroid + Neonicotinoid	EC
Tozim powder	Permethrin	Pyrethroid	SP
AG Vantage 150 EC	Indoxacarb 150 g/L	Oxadiazines	EC
Almectine 20 EC	Emamectin 20g/L	Avermectins	EC
Pyrifore 480	Chlorpyrifox Ethyl 480 g/L	Organophosphate	EC
Tihan 175 0-TEQ (Togo)	Flubendiamide 100g/L+Spirotectramat75g/L	Diamide + Tetramic acid	OD

SP : Soluble Powder OD : Oil Dispersible EC : Emulsifiable Concentrate

The analysis of **Table 2** shows that the pesticide formulations most commonly used around the Kalsom dam in the Didagou watershed area are of the Emulsifiable Concentrate (EC) type for 77.78% of the formulations listed, because they are more practical and suitable for use. Also, nine (09) commercial varieties on cultivated plant species have been identified. They are grouped into eleven (11) active ingredients and eight (08) chemical families in which pyrethroids are more represented with a frequency of 35.71% followed by neonicotinoids (14.29% of cases). These results are in agreement with those of Ohui (2014) who in a similar study in the Nariale watershed in Burkina-Faso found that pyrethroids (43.79%) and neonicotinoids (21.24%) are the families of active ingredients most used by market gardeners. Fairly similar results are generally found in Togo where synthetic pyrethroids (53.20%) and mixtures of synthetic pyrethroids and organophosphates (35.69%) are the chemical families most used in market gardening (Kanda *et al.,* 2013). Also in neighboring Burkina-Faso, pyrethroids and organophosphates are the main families of active ingredients in circulation (65%) Some of the active ingredients of pesticides used in market gardening around the Kalsom dam (such as Chlorpyrifox Ethyl, Lambda-cyalotrin, Permethrin) pose severe risks to human health and/or the environment (PAN, 2019), (Theriault *et al*., 2020).

The intensive spreading of pesticides and other products of unknown formulation, on cultivated soils near the Kalsom dam and/or the Didagou backwater, is a practice which contributes to the pollution of the waters of the dam and the backwater by leaching of pesticides and their decomposition products. Their drainage towards the backwater and/or the dam, especially in rainy weather, is favored by the topology of the soils (sloping downwards towards the mainstay of the backwater and/or the dam). Indeed, the agrochemicals used in the context of agricultural operations are incriminated in the degradation of the quality of soil and water, both surface and underground, particularly at the level of the soil where market gardening is practiced (Ouedraogo *et al*., 2019). These non-biodegradable elements can reach, because of their absorption in high quantities by plants, prohibitive levels for human health (Theriault *et al*., 2021), (Ahoudi *et al*., 2018).

The immediate consequences of the use of pesticides in agriculture are harmful to human health (Plante *et al*., 2022), and environmental degradation (Merlett *et al*., 2022), (Theriault *et al.*, 2020), (Son *et al*., 2017). Health damage results in various diseases caused by contact with pesticides and by the consumption of contaminated food products, fish, meat, fruit vegetables (Hassan and El Nemr, 2020; Eddleston, 2020; Ahoudi *et al*., 2018). In Benin, Biaou *et al*. (2003) and Pazou *et al.* (2006) studied the contamination of environmental components by pesticides used in agricultural environments. The work of Adam *et al*. (2010) has compared the pesticide contamination of agricultural soils to the contamination of drinking water (groundwater) and that of surface water. The study thus made it possible to assess the impact of agricultural treatments on the environment and even human and animal health. The contamination of surface or underground water by toxic substances is closely linked to that of the soil (Pelosi *et al*., 2021). In general, it is imperative to reduce the pressure of chemical pesticides in market gardening around the Kalsom dam. However, particular attention must be paid to producers who do not seem sensitive to the impacts of chemical pesticides on the environment and to the sanitary quality of their production. Since biopesticides are very poorly known by producers despite the intervention of certain projects, the development and promotion of these biopesticides, as well as biological control, would be essential actions in order to reduce the use of insecticides. Finally, raising consumer awareness could encourage public authorities to enforce the national phytosanitary legislative and regulatory texts in force and lead producers to modify their practices, allowing them a better economic valuation of their market garden products from agroecological cropping systems.

3.2 Level of education of market gardeners and pesticides origin

It emerges from the survey that 93.33% of the market gardeners surveyed (all male) did not have the Certificate of First Degree Study (CEPD), i.e. 60% for the primary level and 33.33% for the uneducated. The level of education of market gardeners does not allow them to adopt the appropriate behaviors to avoid health and environmental risks. Thus, only 6.66% of market gardeners surveyed can use the information listed on pesticide labels. Unfortunately, most of the pesticides used by market gardeners are of Chinese, Ghanaian and Nigerian origin, so that the proportion of market gardeners who can read the instructions in English on the labels is very low. Worse still, all the market gardeners declared that they had never had training in the proper use of agricultural inputs. It is very difficult to determine the exact origin of all the phytosanitary products used by market gardeners. Indeed, the data collected from market gardeners around the Kalsom dam reveal a supply chain that is more informal than formal. Most pesticides are purchased from undeclared individuals and especially from street vendors who get their supplies from neighboring countries (especially Ghana). This has been confirmed by the work of Etsè *et al*., 2014 in Togo. Products generally cross borders undeclared. This behavior of market gardeners is reinforced by the insufficiency and the high price of pesticides at the level of the official structure which is in charge of the supply of pesticides (agricultural inputs) to farmers. It is therefore very difficult to know the exact nature of the phytosanitary products used by market gardeners in the city of Dapaong. Even if the products used are effective, it remains very difficult to determine their future and their impact on the environment. Most market gardeners recognize the harmful effects of certain pesticides such as DDT, endosulfan, etc., on the environment and human health, but still continue to use those (Theriault *et al*., 2020; Mawussi *et al*., 2008).

Indeed, the low level of education of producers would cause a lack of knowledge of the main pests of crops and difficulties in reading the methods of use of chemical pesticides appearing on the packaging, thus generating an excessive and sometimes inappropriate use of phytosanitary products (Son *et al*., 2017; Ouedraogo *et al*., 2019). In addition, poor knowledge of cultivated areas makes it difficult for market gardeners to estimate doses (Ouedraogo *et al*., 2019).

3.3 Pesticide packaging management method

Figure 3 highlights the fate of obsolete packaging and pesticides. The analysis of **Figure 3** reveals that burning with 65% of cases is the mode most used to eliminate packaging and expired pesticides, followed by discharges in the field and in the Kalsom dam (10% of cases each). Our results are contrary to those found by Theriault *et.al*. 2021 where 69% of market gardeners in peri-urban areas in Mali throw empty packaging in on the soil thus creating pollution against 17% who burn them. Also, we can notice that 5% of respondents said they wash the packaging for use at home. However, according to the code of good conduct of the Food and Agriculture Organization of the United Nations (FAO), an empty packaging can never be rid of all the traces of pesticides that it contained (FAO, 2002). That said, all those who use them are exposed to the risk of poisoning. The consumer products that respondents put in empty packaging are used by several people, which greatly increases the risk of exposure of populations to pesticides. In general, the method of management of empty pesticide packaging by market gardeners around the Kalsom dam is contrary to that recommended by the provisions of the FAO code which indicates that: "the means of destroying packaging differ from country to country to the other. These means include burial, incineration or recovery by an authorized contracting company. Empty chemical containers should be thoroughly cleaned and rendered unusable (punctured/crushed) before burial. Not all packaging can be burned, especially those whose labels

indicate that they contain a flammable product or aerosols. They must be thoroughly cleaned before being burned. Additionally, burning these packages can cause another hazard if the smoke makes its way onto the roads and becomes a nuisance.

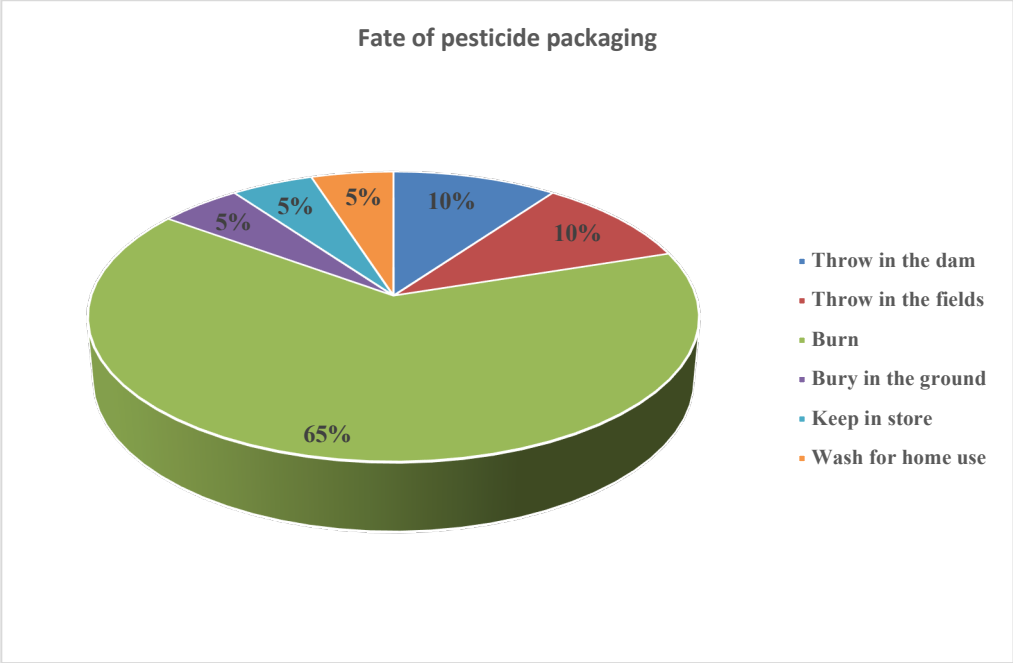

Figure 3. Become obsolete packaging and/or pesticides in the Didagou watershed

The best management of empty packaging must therefore be its rerouting to suppliers, where it can be used again or recycled". This poor management of empty pesticide containers constitutes a danger for people but also for animals which often graze the grass in the fields after harvest. Another consequence of this practice is environmental pollution. Indeed, most of the time, the cans, but especially the discarded empty pesticide sachets end up in a water point and contaminate the entire ecosystem, in particular the aquatic environment. Ultimately, the most significant risks for health and the environment are encountered in the event that empty packaging is reused, thrown away or directly burned (PAN Togo, 2005). In Burkina-Faso (Country neighboring the study area), this problem of empty packaging is partly solved by certain structures such as SOFITEX, which returns the empty packaging to the source house and which, like SAPHYTO, has decontamination and recycling and treats waste (FAO, 2002).

Conclusion

The market gardeners around the Kalsom dam in the Didagou watershed in Dapaong, who are poorly educated, use a variety of pesticides, mainly of the Emulsifiable Concentrate type formulation for 77.78% of the formulations identified. Pyrethroids (35.71% of cases) and neonicotinoids (14.29% of cases) are more represented. The method of management of empty pesticide packaging by these market gardeners is contrary to that recommended by the provisions of the FAO code, thus constituting a danger for people but also for animals. These packaging are thrown either in the dam or in the fields, some are burned (65% of cases), others buried in the ground or stored in stores or washed for domestic use. In view of the poor management of pesticide packaging implicated in this study, the contribution of all the actors involved in the management and use of pesticides is essential.

The intensive spreading of pesticides on cultivated soils near the Kalsom dam is a practice that contributes to the pollution of the waters of the dam by the leaching of pesticides and their

decomposition products. The lack of training and information of market gardeners, illiteracy, poverty as well as non-compliance with the framework relating to the marketing and use of pesticides are the factors that increase the risks of exposure and worsen the health situation of populations.

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