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# CONTRIBUTION TO MONITORING THE QUALITY OF WATER RESOURCES AND THAT OF MARKET GARDEN PRODUCTS PRODUCED IN THE BAGUINEDA IRRIGATED PERIMETER OFFICE AND IN THE BAMAKO DISTRICT

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## ABSTRACT

Pesticides are used in developing countries in excessive or inappropriate amounts and thus inevitably leave residues that could harm human health and the environment. The objective of this study is to contribute to preserving the quality of water resources and market garden products consumed by the populations of the district of Bamako and those of the office of the irrigated perimeter of Baguinéda. To achieve this objective, we conducted surveys on the rational use of pesticides with 40 market gardeners using questionnaires. Subsequently, samples of 35 water samples and 62 samples of fresh vegetables (salad, celery, cabbage, tomato, pepper and African eggplant) were taken.

At the National Health Laboratory, all samples collected were analyzed with a liquid phase chromatograph (HPLC). The QueChers method and that of the Organization for Economic Co-operation and Development (OECD) were used respectively to analyze vegetables and water. All these samples were subjected to analyze of pesticide residues frequently used (Lambda cyhalothrin and Acetamiprid) by the various market gardeners.

The results of the surveys allowed us to know the different types of pesticides that are constantly used by market gardeners and also the methods of use of these chemicals. Indeed, of all the pesticides (100%) used by market gardeners, 89% are approved and 11% are not approved by the Sahelian pesticide committee.

The results of the chromatographic analyzes were evaluated according to the maximum residue limit (MRL). Thus, Lambda cyhalothrin and Acetamiprid were detected in four vegetable samples: Acetamiprid in two eggplants (1.17 ppm; 1.15 ppm) from OPIB, Lambda cyhalothrin in headed cabbage and lettuce with respectively the levels 0.3 ppm and 0.4 ppm in DRA/DB. In general, out of the 97 samples collected, four showed levels above the MRL, i.e. a contamination rate of 4.12%.

Regarding the water samples, no trace of contamination with residues of Lambda cyhalothrin and Acetamiprid was detected.

**Keywords:** Pesticide, market gardening area, OPIB, District of Bamako.

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## 1. INTRODUCTION

Pesticides refer to all chemical or biological products intended to destroy living elements considered harmful (microbes, animals or plants) or intended to oppose their development (Idrissi M, 2010). While the use of these products is often necessary for producers to achieve their production objectives, it remains important to remember that pesticides are toxic and their use can only be accepted or encouraged if the methods of use and the risks to human health and the natural environments likely to be affected are fully understood.

Pesticide residues are a constant concern for the scientific community and public health organizations around the world. Monitoring pesticide residues is a key tool for ensuring compliance with regulations and monitoring compliance with Good Agricultural Practices (Adimi 2018).

The demand for fresh and processed market garden produce is on the rise (Hollinger and Staatz, 2015). This high demand in Mali is partly met by local market gardening production in the peri-urban areas of the capital Bamako (Theriault, 2021).

However, they must deal with insect pests that destroy their production. To improve their yield, market gardeners therefore, for the most part, resort to the use of phytosanitary products and other biocides (Ahouangninou 2011).

Pesticides used for crop protection inevitably leave residues whose presence in food intended for human consumption constitutes a health risk factor for consumers (Amadou 2013).

The WHO estimates that 200,000 people die each year worldwide as a direct result of pesticide poisoning (CAPE, 2009; Belmain et al, 2013). Although synthetic pesticide uses in Africa accounts for only 2-4% of the US$31 billion global pesticide market (Sola al, 2014; Agrow, 2006), the continent is exposed to the highest risk of human mortality associated with pesticide misuse (Williamson et al, 2008). According to United Nations Environment Programme, in sub-Saharan Africa, the potential cost of treating pesticide-related diseases between 2005 and 2020 is estimated at US$90 billion (UNEP, 2011 and Anjarwalla, 2016).

In Africa, market gardening employs 40% of the urban population and contributes 20-30% of the countries' GDP (Tchamadeu 2017).

To combat pests and increase their yields, market gardeners use pesticides, the risks of which they are often unaware of (Soro, 2018). This concern is consistent with the WHO's opinion that food is the main source of exposure to pesticides, ahead of contamination of outdoor and indoor air, soils or indoor dust, the use of pesticides in gardens or on domestic animals (François, 2022). However, the average contribution of drinking water to total dietary exposure to pesticides is less than 5% (Braun, 2022).

Water represents 80% of the weight of plants. It is essential for their growth and transports nutrients: transpiration creates a suction that draws water and mineral salts from the soil from the roots to the leaves.

Agriculture is the main cause of groundwater contamination. Urban and peri-urban sources are significant for surface water (Bernard, 2011).

Pesticides are among the leading causes of death by self-poisoning, particularly in low- and middle-income countries (Jingyuan, 2022).

The targeted areas play a major role in supplying the city of Bamako with vegetables and fruits. The consumption of market garden produce contaminated with pesticide residues is a significant cause of the deterioration of public health. This is why we believe that it is more necessary than ever to diagnose the presence of pesticide residues in water and certain market garden produce.

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The study hypothesis is as follows: the use of pesticides in market gardening is proportional to the contamination of vegetables and the water used to water the plots.

The general objective of this study is to contribute to safeguarding the quality of water resources and that of market garden products produced in the Baguineda irrigated perimeter office and in the Bamako district.

## 2. MATERIALS AND METHOD

### Materials

The materials of our study are: Tomato, African eggplant, salad, celery, pepper and well water.

### Method

The study was carried out in the DRA/DB of the Bamako district and at the Baguineda.

It was a CAP study on the use of pesticides among market gardeners and an analytical study on the search for residues of Lambda cyhalothrin and Acetamiprid in water and vegetables.

A survey was conducted using a questionnaire with 40 market garden producers, including 23 in the 6 communes of Bamako including Samanko and 17 in the villages of Baguineda. The objective of this survey was to know the knowledge, attitudes and practices of market gardeners on the rational use of pesticides.

Data collection was carried out using a questionnaire. Representative sampling of market gardeners was carried out randomly, taking into account the number of sites …

The reagents used are: Acetonitrile; n-hexane; ultrapure water; buffer salt; 2mL disk$^{TM}$ and Primary secondary amine (PSA).

Pure pesticide standards (Lambda-cyhalothrin and Acetamiprid) provided by the International Atomic Energy Agency The pesticides analyzed were based on the standards present in the laboratory. We calibrated the HPLC with the different ranges of standard pesticides based on a standard in order to know the detection limit.

### 2.1. Sampling

Will be included:

- market gardeners who use pesticides with more than 5 years of experience;
- vegetables ready to be consumed and treated with pesticides;
- lambda cyhalothrin and Acetamiprid are the two pesticides selected.

During our surveys, we met 24 market gardeners in Bamako and 16 in the villages of Baguineda. The analyses focused on 41 vegetables and 19 well water samples from market gardening areas in Bamako. In the 6 villages of Baguineda, 21 vegetables and 16 water samples were taken. We were unable to take samples from 5 market gardeners in Bamako because they did not have vegetables ready for harvest.

- **Water sampling**

Water is often wrongly considered to be a simple environment. It is in fact the site of several complex exchanges. It is therefore necessary, from the time of sampling in the field to the analysis laboratory, to respect strict rules of packaging, conservation, storage and transport in order to limit any change in the sample parameters.

This sampling step must be considered a fundamental step in the analysis because the representativeness and reliability of the final result depend on the quality of this operation (Almaric, 1991).

The sampling of well water samples was carried out in compliance with all good practices.

- **Vegetable sampling**

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For vegetables, the choice was made on those intended to supply the Bamako markets. Some are very popular with consumers including:

- lettuce (Lactuca sativa);
- headed cabbage (Brassica oleracea var);
- celery (Apium graveolens L);
- tomato (Solanum lycopersicum L);
- African eggplant (Solanum aethiopicum);
- pepper (Capsicum annuum).

For the sampling of vegetables, the four corners and the center of the plot were targeted. Once collected, the samples are then packaged in aluminum foil and placed in a plastic bag. Each sample is coded on site to ensure anonymity and confidentiality. They were stored in the cooler containing ice for their transport. The analyses were carried out the day after the samples were taken.

**2.2. Analytical techniques**

The analysis of pesticide residues is a complex activity because plant protection products belong to very diverse chemical classes; their dosage therefore requires the use of various techniques and the determination limits requested are increasingly low (Almaric, 1991).

The analysis of pesticide residues focused on Lambda cyhalothrin and Acetamiprid.

❖ **For water**

We will use the liquid-liquid extraction technique (250 mL of water + 25 mL and 20 mL of the extraction solvent).

Shake vigorously for 30 minutes then recover the extraction solvent. Evaporate to dryness and recover the residue with 1 mL of acetonitrile, then take the reading.

❖ **For vegetables**

We used the Quick Easy Cheap Effective Rugged and Safe (QuEChERS) method, 10 g of the matrix add 10 mL of acetonitrile and buffer salt shaker for 1 min then centrifuge. Collect the supernatant, add PSA, then centrifuge again, and take the reading.

**Table I: Analytical parameters for the determination of pesticide residues**

| Active material | Wavelength (nm) | Mobile phase | | Column | Injection volume µL |
|---|---|---|---|---|---|
| | | Water | Acetonitrile | | |
| Lambda cyhalothrine | 205 | 10 | 90 | C 18, 4.6 x 250 mm- 5 micron | 10 |
| Acetamiprid | | 50 | 50 | | |

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**Table II: Standard for Maximum Residue Limit (MRL) of Lambda cyhalothrin and Acetamiprid in different matrices in ppm**

| N° de code | Product to which the MRL applies | Acetamiprid (R) reg,(UE)* 2019/88 | Lambda cyhalothrine reg, (UE)* 2021/590 |
|---|---|---|---|
| 0231030 | Eggplant | 0,2 | 0,3 |
| 0243010 | Cabbage | 0,01 | 0,3 |
| 0251010 | Lettuce | 3 | 1,5 |
| 0256030 | Celery leaf | 3 | 0,7 |
| 0820010 | Chilli pepper | 0,05 | 0,3 |

*Réglementation de l'Union Européenne

### 2.3. Ethics and deontology

The market gardeners' participation in our surveys was voluntary. None of them were subjected to any form of pressure from the administration or management structures. In addition, they were notified that they could stop their participation at any time while being sure that their collected information would be withdrawn.

The questionnaire developed does not contain any passage that undermines morality or customs. The pesticides used for cotton application are used in market gardening.

### 2.4. Data entry and processing

The data were entered into Microsoft Excel and then transferred and processed by the Epi Info statistical software.

## 3. RESULTS AND DISCUSSION

**Table III: List of pesticides identified in the study areas**

| Produits | Effectifs (%) |
|---|---|
| **Lambda cyhalothrin** | **35 (38,9)** |
| **Lambda cyhalothrin + Acetamipride** | **13 (14,4)** |
| **Glyphosate** | **8 (8,9)** |
| Methomyl | 7 (7,8) |
| Emamectine benzoate | 5 (5,6) |
| Chlorpyrifos-ethyle | 5 (5,6) |
| Paraquat chloride | 4 (4,4) |
| Deltamethrin | 2 (2,2) |
| Profenofos + Cypermethrine | 2 (2,2) |
| Others | 9 (9,0) |
| **Total** | **90 (100)** |

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Lambda cyhalothrin, Acetamiprid and Glyphosate were the pesticides most used by market gardeners. These pesticides are used alone or in combination. These results are similar to those of a study carried out in Mali by TOURE et al. 2020 who found 130 Lambda cyhalothrin and 42 Acetamiprid respectively (Toure, 2020).

Based on the frequent consumption of vegetables, we chose five: lettuce, celery, cabbage, African eggplant, pepper in which we will look for pesticides. Table V shows the number and geographical distribution of the samples. In addition to vegetables, we sampled the water used to water vegetables. We carried out exhaustive sampling by including all study sites.

**Table IV: Distribution of samples**

| Type of sample | Bamako number | Baguineda number | Total |
|---|---|---|---|
| Salad (Lettuce) | 18 | 6 | 24 |
| Celery | 15 | 1 | 16 |
| Cabbage | 6 | 0 | 6 |
| African eggplant | 1 | 6 | 7 |
| Tomato | 0 | 5 | 5 |
| Chilli pepper | 1 | 3 | 4 |
| Water | 19 | 16 | 35 |
| **Total** | **60** | **37** | **97** |

Salad (lettuce) and celery were the most sampled vegetables.

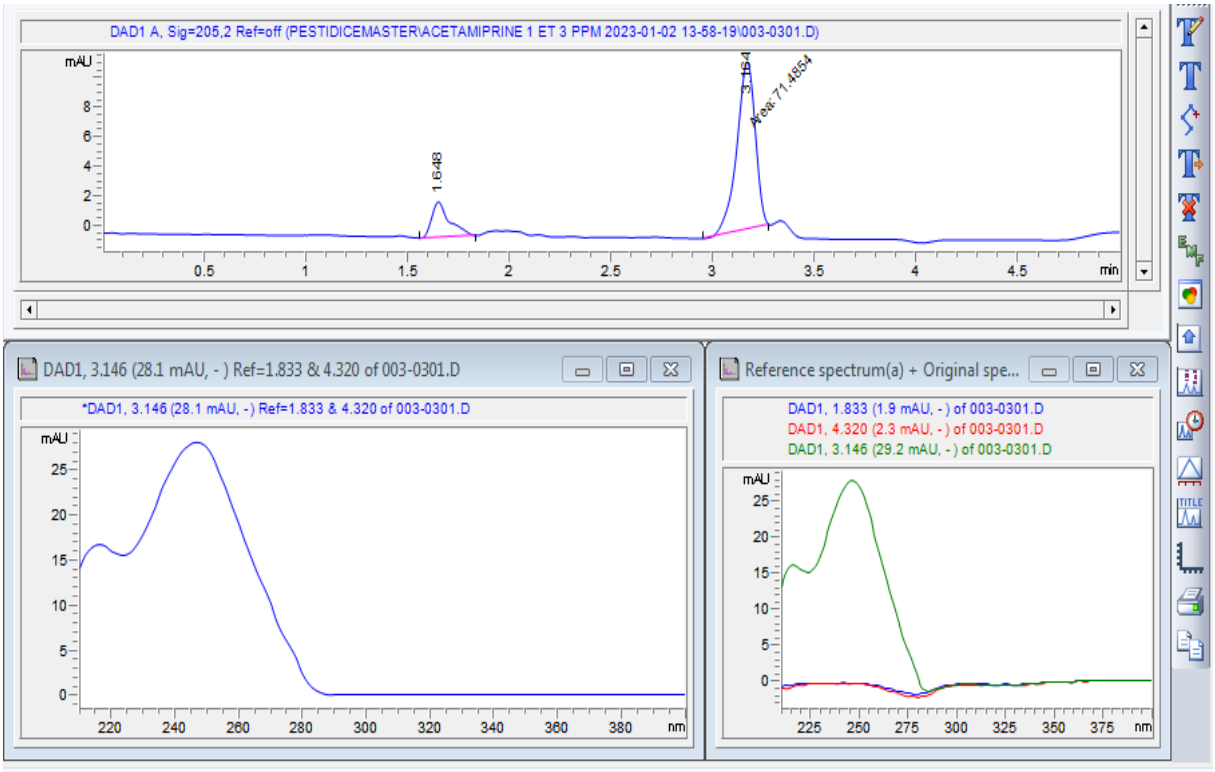

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**Figure 1:** Peak (Tr = 3'164") and Absorption spectrum (λmax = 247 nm) of standard Acetamiprid

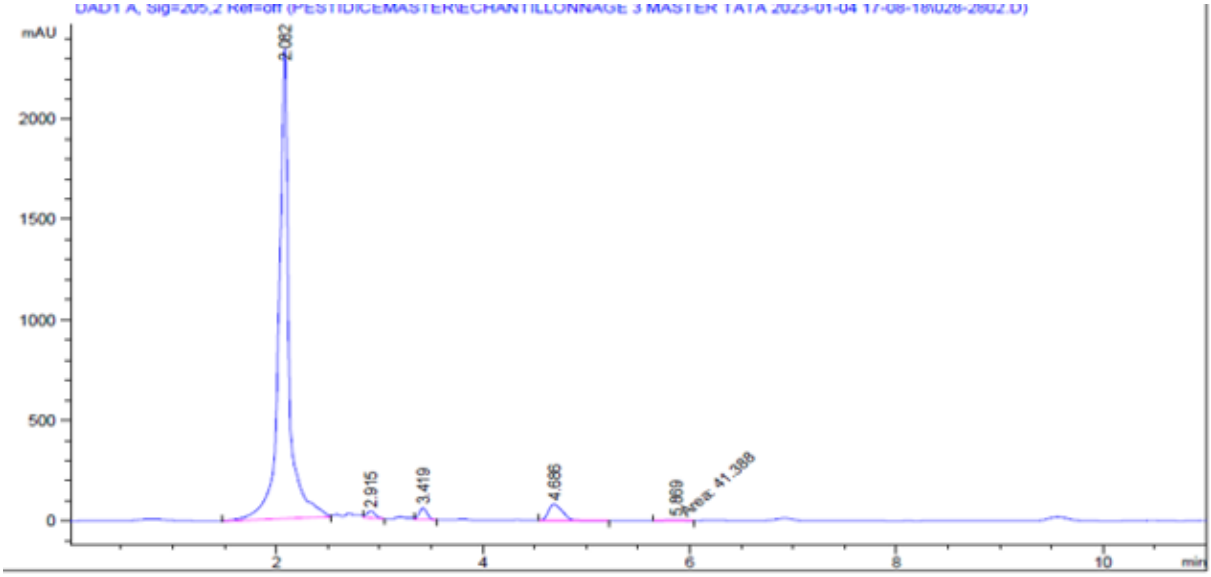


**Figure 2:** Chromatogram of a salad sample contaminated with lambda cyhalothrin identified at a retention time of 5.869 min with a surface area of 41.388

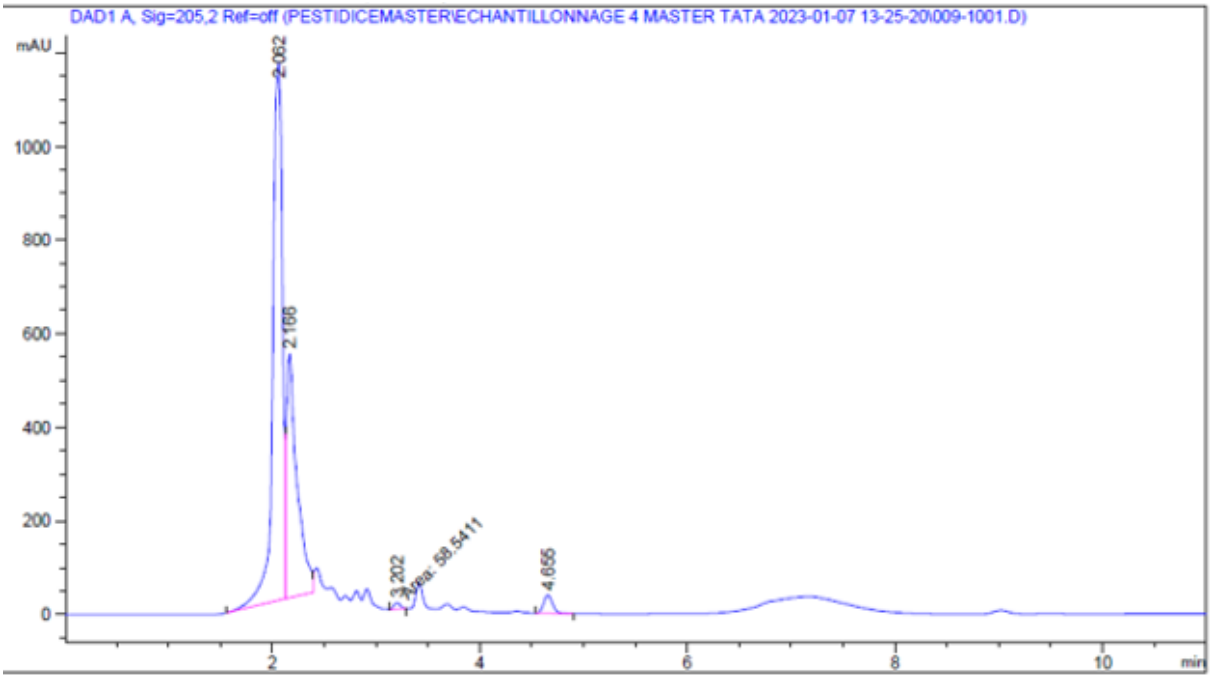


**Figure 3:** Chromatogram of an African eggplant sample contaminated with Acetamiprid identified at a retention time of 3.202 min with a surface area of 58.5411

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We note a much higher level of contamination of 2 eggplant samples that exceeded the MRL. The cabbage sample was at the maximum residue limit. The salad sample was below the MRL. These results are similar to that of a study conducted in Burkina Faso by Yao Pokou Marius Kolia.2015 which detected pesticide residue levels (0-8.31 mg/kg) exceeding the accepted standards for Acetamiprid in African eggplants (Kolia, 2015). On the other hand, they are much higher than those obtained (0.15 µg/kg) in a study carried out by Juan Manuel Montiel Leon 2019 (León, 2019)

**Table VI:** Level of contamination of matrices according to the EU standard

| Matrices | Xenobiotics | Test Portion | Recovery | Fraction | Surface Standard | Surface Sample | Sample Concentration | Résultats in PPM | UE MRL | Conclusion |
|---|---|---|---|---|---|---|---|---|---|---|
| African eggplant | Acetamiprid | 10 | 1 | 0,1 | 10,1 | 59,2 | 5,861386139 | 0,59 | 0,2 | **Contaminated** |
| African eggplant | | 10 | 1 | 0,1 | 10,1 | 58,5 | 5,792079208 | 0,58 | 0,2 | **Contaminated** |
| Cabbage | Lambda cyhalothrin | 10 | 1 | 0,1 | 33,6 | 36,6 | 1,089285714 | 0,11 | 0,3 | **Clean** |
| Salad | | 10 | 1 | 0,1 | 168,7 | 41,3 | 0,244813278 | 0,02 | 1,5 | **Clean** |

African eggplant was the most contaminated (2/7) followed by cabbage (1/6).

Out of the 62 vegetable samples, four were contaminated, one of which had a value lower than the MRL (see Table 6). The water samples were all clean.

## 4. CONCLUSION

Peri-urban market gardening is a booming activity in our country. Bamako remains one of the African cities with too much urbanization. At the same time, the place of market garden products in our diet is making progress. The city's demand for vegetables, both fruits and leaves, is increasing. Thus, increasing production and productivity is more necessary than ever.

To achieve this goal, market gardeners use not only organic and chemical amendments but also pesticides.

However, their low literacy level, and the lack of supervision of market gardeners as well as the lack of information and training on the judicious use of pesticides, they are content with the advice received from resellers. It is undeniable that they have their own experiences that they share among themselves.

During this work, we limited ourselves to two pesticides: Acetamiprid and Lambda cyhalothrin. Our analyses proved Acetamiprid in two samples of African eggplant from the Baguineda area 1.17 PPM and 1.15 PPM.

Lambda cyhalothrin was found in a sample of salad and a sample of cabbage all from Bamako 0.3 PPM and 0.4 PPM

These results must serve as leverage for decision-making if we want the highly prized market garden products not to harm public health and the environment.

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