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Assessment of contamination of soil by pesticides in Djidja's cotton area in Benin

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***Abstract*— *The aim of the research is to assess the level of soil contamination by pesticides in Djidja's cotton area in Benin. Soil samples have been collected in nine (09) cotton fields from 15th to 19th March, 2014. The analysis has been done by gas chromatography after extraction and purification. The results show a soil contamination by glyphosate varying from 0.271 to 0.317 μg/kg, by profenofos varying from 0.109 to 0.130 μg/kg, by acetamiprid varying from 0.088 to 0.153 μg/kg and by cypermethrin varying from 0.165 to 0.190 μg/kg. A regular surpervision program must be planned to limit as possible the soil contamination by pesticides in this township.*

***Keywords*— Agriculture, pesticides, cotton, contamination, soil.**

I. INTRODUCTION

In Benin, the agricultural sector employs 70% of the workforce and contributes 39% to the Gross Domestic Product (GDP), provides 90% of the country's export revenues and contributes about 15% to the revenue of the State (MAEP, 2010). Therefore, it has an important place in Benin's economy. The main cash crop is cotton, whose current production level is largely insufficient to satisfy national and international market high needs. The main food crops (maize, cassava, yam, cowpea, rice, etc.) overcome food needs, but are still below the potential of the ecological conditions of the country (MAEP, 2008). Cultures are submitted to animals attacks and harmful plants. Such situations cause defoliation and destruction of the plants, thus causing huge losses to farmers. To reach the end of such situations pesticides are used (Gbaguidi et *al*., 2004). Pesticides used for cotton production and pest control in the growing of food crops such as beans, maize and vegetables eventually may not only end up on the crops, but also contaminate soil and surface water (Pazou et *al*., 2014). The use of insecticides in agriculture has been incriminated in the emergence of insecticide in insect vectors (Akogbéto et *al*., 2005). Glyphosate can bind to soil particles under certain conditions (Shushkova et *al*., 2009), especially in clay soils. It can be quickly leached in sandy soil, while it may persist for over a year in soils which contain clay (Bergström et *al*., 2011). Even when bound to soil particles, it can be dissolved later in the ground water, in the presence of phosphates (Simonsen et *al*., 2008). Glyphosate has the ability to form chemical complexes with metal ions (Eker et *al*., 2006), that may influence the availability of soil nutrients. It has been proven that glyphosate can change the absorption of agricultural plants, minerals (Zobiole et *al*., 2011). Pesticides can therefore stay in the ground or be washed by rain into groundwater or rivers or transferred to plants, animals and humans. The aim of the research is to assess the level of soil contamination by pesticides in Djidja's cotton area in Benin.

II. MATERIALS AND METHODS

2.1 STUDY AREA

Located between 7° 10' and 7° 40' north latitude, 1° 40' and 2° 10' west longitude, the township of Djidja covers 41.66% of the total area of the department (Zou). With a total area of 2.184 km², it has a sub-equatorial climate next to Sudan Guinea in the northern parts (Akomagni, 2006). This township has a variety of soil types (ferrallitic, ferruginous, vertisols, hydromorphic) and floodplains (SDS, 2004). The township is 145 km² watered by streams where Zou and Couffo are the most important. The vegetation consists of several formations (palm groves, wooded savannah, savannah, forest islands, galleries). The township of Djidja is located in the cotton area of the Centre of Benin. This area is dominated by cereals, tubers and legumes. The population is 80% invested in agricultural activities.

2.2 METHODS

2.2.1- Selection of sampling sites

Three main villages were chosen in the township. The selected villages correspond to experimental areas where phytosanitary treatments are followed. These villages are

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Zakan Kossossa (district of Djidja), Fonpkodji (district of Monsourou) and Aklinmè (borough Agouna). In each village, three sampling areas were selected. The number of samples taken per area is a sample so that three samples were taken from the village.

2.2.2 Soil Sampling protocol

Soil samples were taken from the cotton fields from 15th to 19th of March 2014. The IRGIB-AFRICA laboratory was committed. To do this, the procedure is as follows. Geographic identification of plots was carried out and each plot was defined, that means, an area that has the same historical phytosanitary treatment and even the same vegetative aspect of crop (cotton). Areas (10 m x 10 m) have been delineated in the middle of the field. Before sampling, the surface is cleaned herbs, organic residues and other residues for surface clean soil. Using a spade which has been previously washed with detergent and rinsed with water and acetone, elementary 5 samples were taken at the horizon 0-15 cm along the diagonals and the sides of the square. To take the sample, a hole the depth of the spade was dug with enough space to remove the earth in it. Earth volumes of each sample is important, each sample was mixed in a bucket forming the average sample plot. The samples contained in the bucket were crushed, stones and plant materials were removed and the bucket contents were thoroughly mixed. The equivalent of 1 kg of soil was recovered. The latter was then wrapped in aluminum foil, then put in a plastic bag bearing the words in indelible ink the sample code. Collection sheets stating the place, date of collection and the identity of sampler accompany samples. These were sent to the laboratory in a cool cooler where the conversation was conducted in a refrigerator at 4°C.

2.2.3 Sample Preparation

The preparation of soil samples and pesticide residue analysis were done by the laboratory of IRGIB-AFRICA and inclued the active ingredients namely glyphosate, profenofos, acetamiprid and cypermethrin. These active materials were selected based on the frequency of their use. All chemicals (reagents and solvents) used were of analytical grade. Solvents of a residue grade purity as acetone, dichloromethane, hexane, cyclohexane and the anhydrous sodium sulfate were obtained from Merck Co. (Darmstadt Germany). The water used in the detergent-free distilled water. A standard stock solution (between 75 and 550 pg/mL) was prepared by accurately weighing and dissolving was performed in acetone and stored in a freezer at -30°C without exposure to light. Working standard solutions (5 µg/mL) were prepared by appropriate dilution of the stock standard solution with cyclohexane and stored in a refrigerator (4°C).

Extraction (method soxhlet) of 10 g of pesticide residues from a soil sample is carried out with 50 mL of a mixture of acetone (1/1, v/v) and stirred on a horizontal shaker for 12 hours. Then the extract was filtered and concentrated to 1 mL using exactly to the flow of the rotary evaporator and nitrogen, respectively (Tor et *al*., 2006; Aydin et *al*., 2006). The concentrated extraction was transferred to the traditional cleaning column and the elution was performed with 100 mL of n-hexane/ethyl acetate (1/1, v/v), then the extract was concentrated to exactly 1 mL using a rotary evaporator and the nitrogen released before analysis.

2.2.4 Pesticide Analysis

The determination of pesticides was performed by gas chromatography. A mass spectrometer with high resolution DSQII Thermo was used. The chromatograph used for analysis is a gas chromatograph equipped with a Thermo Scientific split/splitless injector and a temperature controlled GC-MS interface. A smuggler AS 3000 sample was used. 10ul aliquots were injected into the gas chromatograph (GC) operating using a syringe with an injection rate of 20 µL. The initial injection temperature at the nozzle was maintained at 70°C for 5minutes, and increased and maintained for 10 minutes at 310ºC and at 100ºC/minute. The initial temperature at the oven was maintained at 70ºC during 4 minutes, then increased to 150°C at 50°C/minute, then to 235°C with 3°C/minute at last maintained for 3 minutes at 300°C with 50°C/minute. It has been operating the mass spectrometer and the vacuum pump to achieve a different level of "Vacuum" stable injection. The transfer line temperatures, the flow of gas (helium) were settled. The analysis was done with a multiplier filament delay of 5 minutes to prevent the shock ionization filament level.

III. RESULTS

The results of the analysis of the active materials for soils collected are mentioned in figures 1, 2 and 3 as follow.

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Kossossa area

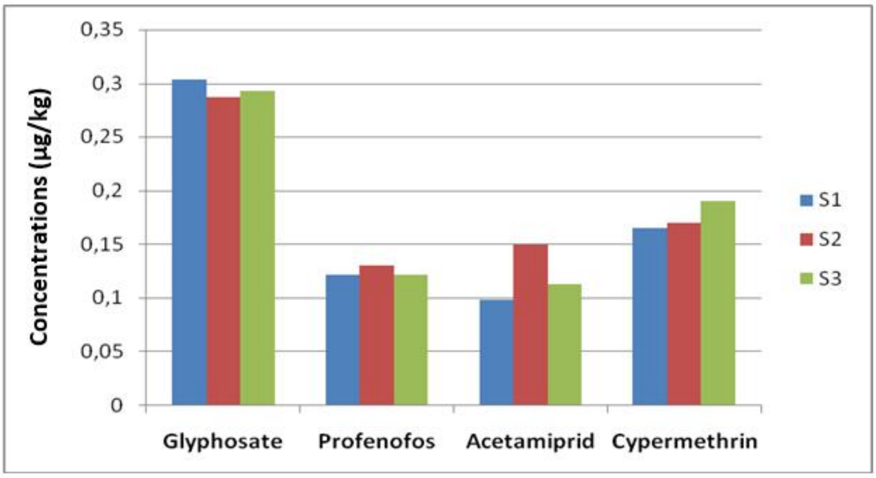

Fig.1: Level of soil contamination of Kossossa area

In the village of kossossa, the glyphosate was chosen in average concentrations of 0.303 µg/kg (S1), of 0.287 µg/kg (S2) and of 0.293 µg/kg (S3); the profenofos was chosen in average concentrations of 0.121 µg/kg (S1), of 0.130 µg/kg (S2) and of 0.121 µg/kg (S3); the acetamiprid was found in average concentrations of 0.098 µg/kg (S1), of 0.149 µg/kg (S2) and of 0.112 µg/kg (S3); the cypermethrin is found in average concentrations of 0.165 µg/kg (S1), of 0.170 µg/kg (S2) and 0.190 µg/kg (S3) for the collected soil samples.

Fonkpodji area

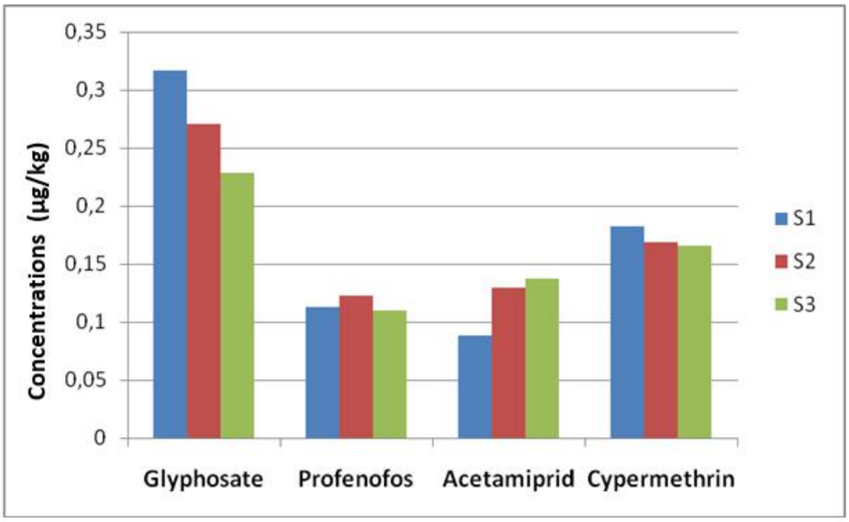

Fig.2: Level of soil contamination of Fonkpodji area

For the collected samples of Fonkpodji area, the glyphosate was chosen in average concentrations of 0.317 µg/kg (S1), of 0.271 µg/kg (S2) and of 0.228 µg/kg (S3); the profenofos was chosen in average concentrations of 0.113 µg/kg (S1), of 0.123 µg/kg (S2) and of 0.110 µg/kg (S3); the acetamiprid was found in average concentrations of 0.088 µg/kg (S1), of 0.129 µg/kg (S2) and of 0.137 µg/kg (S3); the cypermethrin is found in average concentrations of 0.182 µg/kg (S1), of 0.169 µg/kg (S2) and of 0.166 µg/kg (S3).

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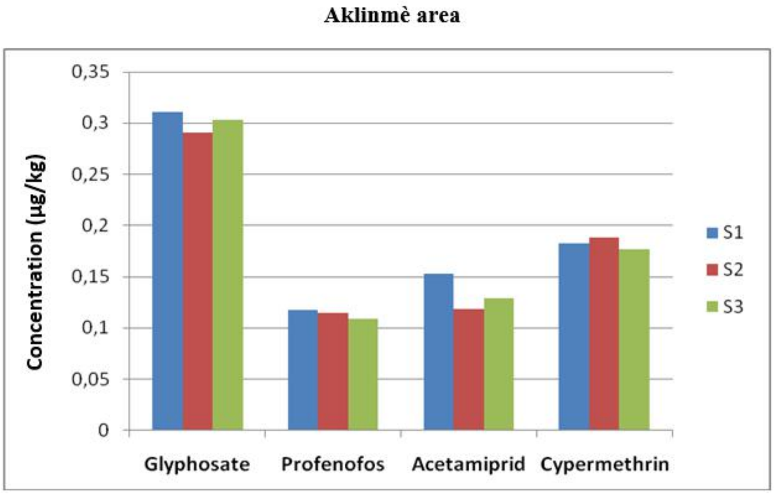

Fig.3: Level of soil contamination of Aklinmè area

In the collected soil samples at Aklinmè, the glyphosate is found in average concentrations of 0.311 µg/kg (S1), of 0.291 µg/kg (S2) and of 0.303 µg/kg; the profenofos is found in average concentrations of 0.118 µg/kg (S1), of 0.115 µg/kg (S2) and of 0.109 µg/kg (S3); the acetamiprid was chosen in average concentrations of 0.153 µg/kg (S1), of 0.119 µg/kg (S2) and of 0.129 µg/kg (S3); the cypermethrin was chosen in average concentrations of 0.183 µg/kg (S1), of 0.188 µg/kg (S2) and of 0.177 µg/kg (S3).

The average concentrations in profenofos and in acetamiprid in the three villages soils are relatively low compared to glyphosate and cypermethrin.

IV. DISCUSSION

Soil samples analyzed showed the presence of glyphosate at average concentrations more than those of the other active materials. These concentrations vary between 0.271 to 0.317 µg/kg in all soil samples. One of glyphosate features is its strong ability to bind to soil particles, that's why its particularly high Koc index (24 000mL/g) (Delabays and Bohren, 2007). Average levels of cypermethrin in all samples vary between 0.165 to 0.190 µg/kg and are superior to those of profenofos which vary between 0.109 and 0.130 µg/kg, but lower than those found by Nafees and Jan (2009) in the valley of Swat. The average concentrations of acetamiprid vary between 0.088 and 0.153 µg/kg in soil samples. The average levels of profenofos and acetamiprid found are lower than those found by Adam et *al*. (2010) in Gogounou, Kandi and Banikoara and also lower than those found by Ngan et *al*. (2005) in Cameroun. The total use of herbicides, insecticides and land pressure with the abandonment of the fallow are potential risks to lower fertility and contaminate soil. However, soils are constitute of ecosystems and the biodiversity of these ecosystems can not be compared both in terms of wealth and biomass and many functions provided by the soil fauna are harmful to agricultural production (Aubertot et *al*., 2005). Some invertebrates living on earth involved in maintaining the structure of soil and greatly improve the quality of these areas and others involved in the decomposition process that leads to nutrient recycling. Pesticides can, for example, cause among microbial communities in the emergence of populations, including bacterial, could degrade, with consequences increasing the dose or frequency of application and therefore deleterious effects on wildlife and flora (Le Roux et *al*., 2008). It is clear that the pesticides that have been used for many years in the township have probably destroyed the soil or at least modified living organisms that are present. Therefore, due to the destruction of soil ecosystems, it is highly likely that these pesticides have seriously damaged their fertility.

V. CONCLUSION

Soil analyzes showed the presence of pesticides in the areas. The average levels of glyphosate and cypermethrin are highest. The mean levels of other active materials are generally low. The future of its active materials in the soil varies according to their nature and their chemical composition and environmental risks are even greater than these toxic products are used on surfaces and in doses/high frequencies. Thanks to the results of the analyzes of residues of pesticides involved in the work, to produce more without pesticides is no longer a utopia because these chemicals are very badly used in Djidja. A regular surpervision program must be planned to limit as possible the soil contamination by pesticides in this township.

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REFERENCES

[1] Adam S., Edorh P., Totin H., Koumolou L., Amoussou E., Aklikokou K. et Boko M. (2010). Pesticides et métaux lourds dans l'eau de boisson, les sols et les sédiments dans la ceinture cotonnière de Gogounou, Kandi et Banikoara. International Journal of Biological and Chemical Sciences, 4 : 1170-1179.
[2] Akogbéto M.C., Djouaka R. et Noukpo H. (2005). Utilisation des insecticides agricoles au Bénin. Bull. Soc. Pathol. Exot., 98 (5) : 400-405.
[3] Akomagni L.A. (2006). Monographie de la commune de Djidja. Programme d'Appui au Démarrage des Communes, Afrique Conseil, 44 p.
[4] Aubertot S.N., Barbier J.M. et Carpentier A. (2005). Pesticides, agriculture et environnement, réduire l'utilisation des pesticides et limiter leurs impacts environnementaux. Rapport d'expertise scientifique collective, INRAB et CEMAGREF, France, 86 p.
[5] Aydin M.E., Tor A. and Ozcan S. (2006). Determination of selected polychlorinated biphenyls in soil by miniaturized utrasonic solvent extraction and gaz chromatography-mass selective detection. Analytica chimica Acta, 577 : 232-237.
[6] Bergström L., Borjesson E. and Stenström J. (2011). Laboratory and Lysimeter Studies of Glyphosate and Aminomethylphosphonic Acid in a Sand and Clay Soil. Journal of Environmental Quality, 40 : 98-108.
[7] Delabays N. et Bohren C. (2007). Le glyphosate: bilan de la situation mondiale et analyse de quelques conséquences malherbologiques pour la Suisse. Revue Suisse Vitic. Arboric. Hortic., 39 (5) : 333-339.
[8] Eker S. Ozturk L., Yazici A., Erenogly B., Römheld V. and Cakmak I. (2006). Foliarapplied Glyphosate substantially reduced uptake and transport of iron and manganese in sunflower (Helianthus annuus L.) plants. J. Agric. Food chem., 54 : 10019-10025.
[9] Gbaguidi B., Allagbé C., Bani G., Dohoué E., Gbèboutin E. et Houndékon R. (2004). Analyse des aspects socio-économiques de l'utilisation des POP. Rapport final, MEHU, Cotonou, Bénin, 34 p.
[10] Le Roux X., Barbault R., Baudry J., Burel F., Doussan I., Garnier E., Herzog F., Lavorel S., Lifran R., Roger-Estrade J., Sarthou J.P. and Trommetter M. (2008). Agriculture et Biodiversité. Valoriser les synergies. Expertise scientifique collective, synthèse du rapport. INRA, France, 116 p.
[11] MAEP (Ministère de l'Agriculture, de l'Elevage et de la Pêche) (2008). Plan Stratégique de Relance du Secteur Agricole au Bénin. Orientations stratégiques et Plan d'action, Cotonou, Bénin, 70 p.
[12] MAEP (Ministère de l'Agriculture, de l'Elevage et de la Pêche) (2010). Analyse de l'insécurité alimentaire et des inégalités d'accès à l'alimentation au Bénin. Rapport, Cotonou, Bénin, 27 p.
[13] Nafees M. et Jan M. (2009). Les résidus de cyperméthrine et de l'endosulfan dans les sols de la vallée de Swat. Sol et Environnement, 28 (2) : 113-118.
[14] Ngan C.K., Cheat U.B., Wan Abdullah W.Y., Lim K.P. et Ismail B.S. (2005). Sort de chlorthaloniel, Chlorpyrifos et Profénofos dans une ferme de légumes à Highlands de Cameroun, la Malaisie. Focus, 5 (1-2) : 125-136.
[15] Pazou E., Glin L.C., Vodouhè D.S., Fanou J., Babadankpodji A.P., Dassou S., Vodouhè S., van Hattum B., Swart K. and van Gestel C.A.M. (2014). Pesticides contamination of the Dridji cotton plantation area in the Republic of Benin. African Journal of Food, Agriculture, Nutriton and Development, 14 (3): 8885-8902.
[16] SDS (Schéma de Développement Sectoriel) (2004). Document de synthèse, Diagnostic, Vision et Planification des projets sur 2004-2008 du secteur de l'agriculture, de l'élevage et de l'exploitation des ressources naturelles de la commune de Djidja, PADeCoM/Zou, 159 p.
[17] Shushkova T., Ermakova I. and Leontievsky A. (2009). Glyphosate bioavailability in the soil. Biodegradation, 21 : 403-410.
[18] Simonsen L. Fomsgard I.S., Svensmark B. and Splid N.H. (2008). Fate and availability of glyphosate and AMPA in agricultural soil. Journal of Environmental Science and Health, Part B, 43 : 365-375.
[19] Tor A., Aydin M.E. and Ozcan S. (2006). Determination of selected of polychlorinated biphenyls in soil by miniaturised utrasonic solvent extraction and gaz chromatography-mass selective detection. Analytica Chemical Acta. 577 (2) : 232-237
[20] Zobiole L.H.S., Kremer R.J., Oliveira R.S.jr and Constantin J. (2011). Glyphosate affects chlorophyll, nodulation and nutrient accumulation of "second generation" glyphosate- resistant soybean (Glycine max L.). Pesticide Biochemistry and Physiology, 99 : 53-60.