

Effectiveness insecticide of LLINs (Olyset net and Permanet 2.0) in condition of land use in N'gatty and Allaba villages, in lagoon environment of Côte d'Ivoires

Abstract:

Assessment of the insecticide effectiveness of Olysetnet and Permanet 2.0 was performed respectively for 36 and 24 month follow-up under field use conditions in N'gatty and Allaba, in lagoon environment of Côte d'Ivoire. After identifying users of LLINs in households, 580 Olysetnet and 100 Permanet 2.0 were distributed to N'gatty and Allaba. Their effectiveness has been regularly assessed by a questionnaire sent to users, by bio assays contacting females of a sensitive reference strain of tests *An. Gambiae* "Kisumu" with netting materials and the determination of residual amount of insecticide by high pressure liquid chromatography (HPLC) in samples of nets in use. According to users, loss of effectiveness of LLINs was experienced after 2-3 months of use. Bio assays conducted before the distribution of LLINs have confirmed their efficacy on the sensitive strain mosquito. Mortality rates at 6 months were 37.8% with Olyset and 38.4% with Permanet 2.0. After six months, the doses of permethrin and delta methrin were respectively 666.25 mg/m² or 57% of the initial dose (1168.75 mg/m²) in net Olyset and 15.30 mg/m² or 35% of the original dose (43.40 mg/m²) in Permanet 2.0. The concept of LLINs, as defined by WHO, seems to know the limits when they are used and subjected to washing practices in the field conditions in Côte d'Ivoire. The washing methods which clearly differ from the standard WHO method of washing nets, accelerate the degradation of the insecticide and shorten their effectiveness over time.

Keywords: Efficiency, LLINs, N'gatty, Allaba, lagoon environment, Côte d'Ivoire.

1. Introduction

The promotion of the ITN is listed as one of the action plans of national programs against malaria in most African countries south of the Sahara. Which results in recent years by the distribution of ITNs to vulnerable populations by the Global Fund to Fight against AIDS, malaria and tuberculosis through national programs against malaria (PNLP). However, one of the major problems of the widespread use of impregnated mosquito nets, is the irregular treatment is rarely carried out by communities. In operational terms, this re-treatment is not always guaranteed due to the non availability of insecticide formulations recommended for treating mosquito nets, their cost, the lack of control impregnation techniques and often non-operating of the centers impregnations. One way to solve this handicap for the use of conventional ITN is the development of long-lasting insecticide-treated nets (LLINs) which are pre-impregnated and requiring no restatement for the duration of use which varies from 3 to 5 years depending on the quality of the fibers¹. These LLINs that are an interesting alternative to the problem of re-treatment of conventional nets, need to control object to evaluate and monitor their effectiveness in field conditions. Thus WHO encourages large-scale field studies to confirm in different operational conditions the duration of the effectiveness of LLINs in the prevention of malaria and other vector-borne diseases. However, the actual duration of the effectiveness of long-lasting insecticide-treated nets (LLINs) in natural conditions, is unknown communities. Knowledge of longevity in terms of efficiency preventing all touch between human and mosquito remains essential for any program promoting the use of LLINs as a means to fight against malaria.

It is in this context that this work was carried out in lagoon coastal environment in the villages of N'gatty and Allaba to evaluate the duration of effectiveness of insecticide in the LLINs under field use conditions in Côte d'Ivoire.

2. Materials and methods

2.1. Study sites

This study was conducted in Côte d'Ivoire, between 4° 30' and 10° 30' north latitude and between 8° 30' and 2° 30' west longitude, with an area of 322 462 km². The fieldwork was carried out in the area of the lagoons specifically in the villages of N'gatty and Allaba that are distant about 800 meters in the department of Dabou. The department of Dabou is located between 05° 18' north latitude and 04° 27' west longitude. It covers an area of 2257.8 km². It is bounded to the south by the department of Jacquelineville, north by the department of Agboville, east by the district of Abidjan and in the west by the department of Grand-Lahou. This department of Dabou consists of 56 villages including N'gatty and Allaba place where our fieldwork were conducted (Figure 1).

2.2. Survey of LLINs washing practices and training clusters

Three months after the distribution of LLINs in households, a survey of washing practices was conducted using a questionnaire. This survey covered women who installed and washed at least once their LLINs. The questionnaire eight selected variables (quality of washing water, washing soaps, washing mode, quantity of rinsing water, frequency of washing, dipping, so a king soap and drying mode). Based on these eight variables, washing clusters were formed. Indeed, a cluster consists of women with the same washing practices without exception. At the end of the investigation, it was recommended to respondents to keep their washing practice. However, those who changed their washing methods, are outputs from the different clusters formed. The collected data were entered and analyzed using Excel software to form the different clusters.

2.3. Socio-anthropological surveys

The effectiveness of LLINs was estimated each quarter in households by socio-anthropological survey tracking wash clusters and conduct Focus Group Discussions (FGD) with the different communities of women. The focus group discussions have been together in one place a group of women using LLINs to hear their points of view by are corded interview. During these surveys and focus group discussions, the investigator is accompanied by an interpreter who can easily expressed in the local language.

2.4. Bioassays

Samples (21 x 21 cm) were regularly taken from each side of LLINs in use and packed separately in aluminum foil before bioassays. For each net, 50 mosquitoes were introduced into 5 cones, 10 by cone and opposite the LLIN. At least four different LLINs were used under the same conditions and tested simultaneously in order to obtain an average of the efficiency of LLIN 4 (10 x 5 x 4 = 200 mosquitoes). The net was first fixed on the widest part of the cone with the aid of a rubber band. Exceptionally un-impregnated new netting materials were used to cover the outer face of the samples LLIN net Olyset to prevent the escape of mosquito mesh. The KD60 indicates the percentage of mosquitoes shocked 60 minutes after being exposed to the net. Mosquitoes are let in the cupeven 23 hours (total 24 hours after exposure) before the dead individuals (or maimed by the loss of two legs or a wing) is counted. Functional mortality (FM) indicates that the mutilated mosquitoes that cannot fly, will eventually fall down and die. For WHO, a treated net is effective if the KD60 exceeds 95% and 80% of FM.

2.5. Assay of the residual amount of insecticides by HPLC

A sample of 100cm² was cut in two of the five samples of nets used for HPLC analysis. These two samples were taken respectively on the horizontal face (roof) and on one of our side faces of the LLIN. Samples of 100 cm² thus obtained were cut into small pieces to be soaked in the organic solvent under mechanical agitation. The sample is thus immersed in a solvent bath, which will extract the insecticide of the net fiber. The extraction liquid containing the insecticide is then injected in to an HPLC system (high performance liquid chromatography). This device with along column which passes a constant flow of diluents which is the mobile phase. When injecting the extract containing the insecticide in the mobile phase in the HPLC column, the various chemicals contained in the extract are separated because the migration velocities of these substances depend on their molecular structures. After the column is a detector which records the amount of each of the different molecules that have migrated through the column. Each insecticide is recognized by the injection of a pure solution of this material, and its amount in the liquid solution is calculated by the simultaneous addition of a known amount of another chemical in the same column.

3. Results and discussion

3.1. Design efficiency by women in households

In general, the effectiveness of LLINs has been confirmed by the user in the first days of their installation in households. Women in households have shown that efficiency by observing dead cockroaches, spiders and salamanders and especially the lack of mosquitoes in their home. However, this has not been observed after 2-3 washes mosquito nets. During the "focus group discussions," women estimated at six months times to use LLINs before they lose their insecticidal efficacy. According to them, it is from this period that the mosquitoes began to report in the house and sometimes in LLINs (Olyset net). However, some users have confirmed the effectiveness of their net (Olyset net) after more than 18 months of use.

The use of insecticide-treated net can effectively reduce morbidity and mortality due to malaria in a variety of epidemiological settings. Promoting the use of ITNs is one of our strategies recommended by WHO in the fight against malaria. The assessment of the duration of efficacy of LLINs in natural conditions allow their extension, if they retained their effectiveness as long on the field and in laboratory conditions. It came for us to assess first, the duration of the effectiveness of LLINs to the socio-anthropological level and secondly, at the biological level and then assess the information gathered by the chemical assay of the residual amount insecticide for the use of LLINs.

The concept of efficiency as users LLIN is a direct observation that reflects the reality on the ground. The majority of these women felt that nets lose their effectiveness when the situation observed in the early days of the use of these nets has changed. Indeed, the LLIN installation led to the disappearance and death of mosquitoes, cockroaches, spiders and salamanders sometimes. Our results are in accordance with observations made in Liberia after the distribution of LLINs in households³. When they see the opposite, the effectiveness of LLINs is automatically challenged. The impact of some important parameters such as the soap washing, soaking and the washing frequency could not be evaluated. In reality, none of these parameters depended on the use, has been kept constant over time. For example the washing soap change was observed in almost all women. The trend has been the use of all kinds of soap (liquid, solid, powder, traditional or modern) available on laundry day. Indeed, no particular condition washing was imposed on women. They were free to choose the method or way that would agree to make their own the net. Contesting has the advantage of evaluating the effectiveness of impregnated carriers by analyzing two important parameters. Polyethylene is a material on which the mosquito clings very difficult, it will have no choice but to remain in flight or landing on the substrate (net fiber). The effectiveness of the insecticides is measured by the knock-down effect (KD) and the



mortality they generate after 24 hours of observation. The KD effect is observed for one hour at regular time intervals ranging from 5 to 10 minutes⁴. According WHOPE⁵, a mosquito net is still effective if the knock-down effect after 60 minutes and/or mortality are respectively greater than 95% to 80%. WHO said the report, estimating the effectiveness of mosquito net at any given time, must take into account the average of contact in at least 200 mosquitoes ($5 \times 10 \times 4 = 200$) with

four different nets. During this study, 4 nets should be used under the same conditions. Given the above, evaluation of the effectiveness of LLINs took into account the duration of use (months) that does not depend on the number of washes.

3.2. Insecticide effectiveness of LLINs in time

Before the distribution of LLIN, a series of contests were performed to evaluate their initial efficiency. After random selection of 16 Olyset net and 13 Permanent 2.0 in different stocks. The tests were performed on 2135 female of *Anopheles gambiae* Kisumu. All mosquitoes (100%) were stunned after 60 minutes of observation with both LLINs. The mortality rate was 98.71% with Olyset net and 99.35% with Permanent 2.0. The effectiveness of Olyset Net was conducted for 36 months of use in field conditions. In total 4,502 mosquitoes were contacted net at 6 months, 15 months, 18 months, 24 months, 30 months and 36 months. The number of nets tested ranged from 17 (6 months) to 11 (36 months). After six months of use, the average rate of mosquitoes knocked down (kd) was observed in 61.42% with an average mortality of 35.44%. Of the 17 tested LLIN, the percentage of mortality kd60 and maximum were 83.1% and 67.4% respectively. At the end, the tests carried out in the fifteenth months of use of net Olyset, the percentage of mosquitoes kd60 ranged from 41.7% to 100%, with an average of 72.67%. During the same period, the average mortality of these nets was 41.96%, the minimum was 15% and the maximum of 88.2%. A slight increase in the efficiency of mosquito nets was observed after 15 months of use. Indeed, some have acquired their effectiveness (% kd60 > 95% mortality and > 80%). The percentages kd60 observed after 18 months of use are statistically identical to the fifteenth months ($F = 0.065$; $Df = 1$, $p = 0, 80$). However, the observed mortality varied between 10% and 37.8%, an average of 25.72%. The kd60 percentages of 20.70%, 18.70% and 3.64% respectively, were observed after 24 months, 30 months and 36 months of use. Mortalities induced by bed nets 24-36 months of use was below 10% (Table I). The effectiveness of Olyset net was evaluated after the first wash, and then at intervals of 5 to 35 washes. The selected nets were washed once a month. The evolution of the effectiveness of such bed nets is shown in the graph of Figure 33. In general, the percentage kd60 and mortality were respectively lower than 95% and 80%, after successive washes of Olyset net. However, after the fifth washing, a slight increase in the percentage kd60 was observed (Figure 2). Successive washings have strongly influenced the effectiveness of Oly set net.

The evaluation of the effectiveness of Permanent 2.0 nets was carried out for 24 months of use in field conditions. A total of 3201 female *An. Gambiae* were contacted with Permanent from the third month of use. The tests were repeated after 6 months, 9 months, 15 months, 18 months and 24 months. After 3 months of use, 89.38% and 73.58% of mosquitoes were knocked down respectively (stunned) and killed (Table II). The percentage of Kd60 varied from 75% to 100% and mortality of 73.58% to 80%. In three months of use, some nets have always retained their effectiveness. Six months later, after distribution in households, the percentage kd60 and mortality induced by Permanent were respectively 47.81% and 34.97%. The maximum of kd60 percentage was 67.7%. That of the mortality was 48.4%. At that time, all nets lost their lethal effect on the sensitive strain of *An. Gambiae* Kisumu. However, a slight increase in the knock-down effect was observed from the ninth month of use. Indeed, the statistical analysis of kd60 percentages of the



sixth and ninth month showed no significant difference ($p = 0.04$). From the fifteenth month of use, kd60 percentages and mortality remained very low, until the twenty fourth month in which they were 6.53% and 3.49%, respectively (Table II). Permanent LLINs were evaluated after 1 wash, then at intervals of up to 5 washes (Figure 3). At least 4 nets respecting the frequency of washing per month were used in this evaluation. After the first wash, the percentage kd60 and mortality were 95.04% and 74.38% respectively. These values indicate a reduction in the lethal effect of Permanent nets on the sensitive strain of *An gambiae*. The bio assays after the fifth and the tenth wash have observed 56.68% and 59.56% respectively of kd60. Mortality rates were 27.36% and 23.11% respectively after 5 washes and 10 washes. These values are statistically identical ($p > 0.05$). From the tenth washing, the effectiveness of nets Permanent remained low until the twentieth wash where the percentage of kd60 and mortality were 12.37% and 5.19% respectively.

Before distribution, the three types of LLINs have been effective on the sensitive strain of *Angambiae*. This effectiveness is confirmed by the quantities observed in these insecticides LLINs in the same period. Indeed, the amount of different insecticides in each type of LLIN is sufficient to obtain a lethal effect on sensitive mosquitoes. Previous studies on insecticide-treated nets⁶ estimated the duration of their effectiveness in six months under field use conditions. This observation led us to fix the completion of the first assessments of the effectiveness of LLINs (Olyset net) after the sixth month of use.

The results of cone tests after six months of use of LLINs Olyset net, showed a drop in insecticide efficacy. Indeed, in this period, the average percentage of kd60 and the mortality 24 hours later are lower than the values of WHOPE standards⁵. This observation explains the attachment to three months achieving the first bioassays with both Permanent 2.0.

The decrease in insecticide efficacy of LLINs Olyset net, is not the fact of the elimination of the amount of permethrin incorporated into the fibers. Indeed, the residual amount of permethrin in Olyset net fibers after six months of use is greater than the maximum dose ($666.25 \text{ mg} / \text{m} > 500 \text{ mg} / \text{m}^2$) recommended by WHO for impregnating ordinary nets⁷. This large amount of insecticide is contained inside and not on the surface of the fibers. The surface free of insecticide can not have lethal effect on mosquitoes.

The results of tests carried out after the fifteenth and eighteenth month of use of Olyset net indicates revival of the effectiveness of certain nets. Indeed, these nets have recovered their initial effectiveness, kd60 with a percentage of 100% and 88.2% mortality. The amount of permethrin in Olyset net fibers after 15 months and 18 months respectively is $595 \text{ mg} / \text{m}^2$ and $445 \text{ mg} / \text{m}^2$. There was a diffusion of permethrin from the inside to the surface of the fibers. Thus, the Olyset net regain their effectiveness after regeneration of the insecticide to the fiber surface^{8, 9}. This is what explains the effectiveness of Olyset net after 36 months of use in field conditions savannah zone of Côte d'Ivoire¹⁰. Distribution or regeneration of insecticide happens naturally. However, it is accelerated when the nets are exposed to heat¹¹. Regeneration of the permethrin is effective when the net is exposed to sun light for 8 hours for 5 consecutive days¹² or merely for 8 hours at a temperature of 35 to 43° C¹³. Regeneration is delayed when the nets are exposed in the shade¹². According to Ikeshoji and Bakote (1997)¹⁴, the Olyset net retain their biological efficacy with permethrin amount estimated at $100 \text{ mg} / \text{m}^2$ if the distribution of the insecticide is effective until the surface of the fiber. After 24 months of use, Olyset have permanently lost their biological effectiveness. This is explained by the non-diffusion of the permethrin from the inside to the surface of the fibers. Because the amount of permethrin ($216 \text{ mg} / \text{m}^2$) in net Olyset evaluated at this time is within the margin of dosage required for impregnating ordinary nets with



permethrin. The margin determination of permethrin is 200 -500mg / m⁷. Under these conditions, the biological effectiveness of the mosquito net is highly dependent on the effectiveness of the distribution of the insecticide in the fibers.

3.3. Residual amount of insecticide in the insecticide fibers in use

The quantities insecticides were measured in 10 samples of bed nets of each type of LLINs, a total of 20 samples. The amount of permethrin was 1168.75mg/ m² in Olyset net fibers.

In Permanet fibers, the dose of deltamethrin was 43.40mg/ m². The quantities of insecticide residues were raised during the duration of use LLIN in field conditions. In total, 72 samples of mosquito net and 720 lyset Permanet 2.0.

The permethrin residues were identified in the samples before Olyset net distribution (T₀), after six months, 15 months, 18 months, 24 months and 36 months of use. The dose of permethrin in Olyset fibers before the distribution was on average 1168.75mg/ m². After six months of use, the dose of permethrin significantly lowered (Figure 4). She was 666.25mg/ m², or 57% of the initial dose. This corresponds to a 42.99% loss in the amount of permethrin in the nets. After 6 months of use, the amount of permethrin was 595mg/ m². Thus, the loss in the amount of permethrin between the sixth and fifteenth month is estimated at 71.25mg/ m². Three months later (18 months of use), the amount of permethrin in the net Olyset fibers, is estimated at 445mg/ m². The amount of permethrin to 24 months of use (216 mg /m²) is still comparable to the impregnation of common mosquito dose that varies from 200 to 500mg/ m². The dose of permethrin faded gradually over time in Olyset net fibers (Figure 4). After 36 months of use, permethrin dose was 55mg/ m², ie 4.70% of the initial dose (T₀). At this stage, loss of permethrin is estimated at 95.29%. Figure 5 shows the evolution of the amount of permethrin in the fibers of the Olyset net based on the number of washes. After 5 washes, the amount of insecticide contained in the Olyset net fiber is estimated at 647.49mg /m², or 55% of the initial dose. Permethrin was continuously removed until the thirtieth wash where the dose is 97.38mg/ m², or 8% of the initial dose. Delta methrin residues were identified in samples Permanet 2.0 before the timing (T₀), after 6 months, 9 months, 15 months, 18 months and 24 months of use. Before distribution (T₀), the dose of delta methrin in Permanet 2.0 fibers was 43.4mg/ m². After six months of use, the dose of permethrin was 15.3mg/ m², or 35.25% of the initial dose. The loss of the amount of delta methrin six months of use, is 28.1mg/ m², or 64.35% of the initial dose (Figure 6). This dose of deltamethrin is comparable to that used for the impregnation of conventional nets (15-25mg /m²). After 9 months of use, the amount of deltamethrin is estimated at 4.5mg/ m² in Permanet nets. This corresponds to 10.36% of the initial dose (T₀). The loss is estimated at 89.64% of the amount of deltamethrin. The amount of deltamethrin faded gradually over time in Permanet fibers (Figure 6). After 24 months of use, the dose of deltamethrin was 0.20 mg/ m², or 0.46% of the initial dose. Figure 7 shows the change in the amount of deltamethrin in Permanet 2.0 fibers. After 5 washes, the amount of deltamethrin contained in the fibers is estimated at 16.54mg /m², which is 38.11% of the initial dose. After 10 washes, there is 4.41mg/ m² in LLINs Permanet 2.0 or 10.16% of the initial dose (Figure 7). In the fifteenth washing, there is less than 1 mg /m² of deltamethrin in Permanet 2.0.

Successive washes were strongly involved in reducing the effectiveness of Olyset net. This observation was also made by some authors ¹¹ who observed a drastic decline in the effectiveness of Olyset net after only two washes in the laboratory. On the contrary, Malaysia, after 15 washes with water only, Olyset nets retained their effectiveness on *An. Maculatus* (95%) and *Ae. Aegypti* (100%) ¹⁵.

The effectiveness of LLINs Perma Net before the distribution is confirmed by the amount of deltamethrin evaluated before any human action. The new nets are the 43.4mg / m² uniformly distributed deltamethrin in fiber (inside to the

surface). PermaNet®2.0 is a net in which deltamethrin dosed at 50 mg /m², is mixed with a resin which coats the polyester fibers. Pyrethroid thus fixed on the support is gradually released by the resin, so that the net remains effective even after several washes⁴. The loss of efficiency of Permanent observed after six months, is due to conditions that are very different from those performed in the laboratory¹⁶. Furthermore, in the same period the amount of deltamethrin was 15.3 mg / m². The gradual relaxation of deltamethrin by the resin on the surface of the net fiber did not appear effective.

Similar observations were made in Burkina Faso¹⁶. These authors observed mortality indicates the decline in the effectiveness of certain LLINs after 6 months of use in field conditions in rural areas in Burkina Faso. Indeed, the observed mortality in Burkina Faso has varied from 41% to 100%. On the contrary, our results strongly differ from those obtained in Thailand¹⁷, Uganda¹⁸ and India^{19;13}.

The complete loss of the effectiveness of the Perma Net nets after nine months, was due to the leaching of more than 90% (-38.99 mg /m²) of the initial amount of deltamethrin. A loss of about 91.5% (- 43.4 mg /m²) of the original amount (47,1 mg /m²) delta methrin was observed in Burkina after 12 months of use¹⁶.

4. Conclusion

Monitoring LLIN Olyset net for 36 months showed a change in its biological efficacy in time. Indeed, after 6 months of use, a decrease in the lethal effect of permethrin is observed. At this time the amount of permethrin (666.25 mg / m²) is held inside the fibers. The contact of mosquitoes with the surface of fiber devoid of insecticide does not cause the death of them. However, Olyset net resume their efficiency after the fifteenth and eighteenth months of use. Part of the amount of permethrin contained in the fibers has migrated from the interior to the surface to ensure regeneration. From the twenty-fourth month of use, the LLIN Olyset net lost their biological effectiveness. However, the nets could be still effective, if the regeneration was effective in the fibers. Indeed, at this time of the use of LLINs Olyset net, HPLC analysis revealed an amount of insecticide (216 mg /m²) in the range of the dose (200-500 mg /m²) of recommended permethrin for re-treatment of ordinary nets.

The decrease in efficacy was observed after the sixth month of use of Permanent 2.0 nets in field conditions. By against the amount (15.3 mg / m) deltamethrin in the fiber 6 months of use is greater than the lowest dose (15 mg / m) required for the re-treatment of common mosquito. There was no diffusion of deltamethrin in Permanent fibers. The lack of regeneration deltamethrin is the cause of the inefficiency of Permanent 2.0 after 6 months of use in field conditions. However, after 9 months of use in field conditions, Permanent 2.0 nets permanently lose their insecticidal efficacy, because the amount (4.5 mg / m²) of insecticide

is significantly less than the smallest recommended dose of deltamethrin for the re-treatment of nets. The concept LLINs, as defined by the WHO seems to know the limits when the nets are used and subjected to community practices wash in Côte d'Ivoire. Washes modes on the ground which are significantly different WHO standard washing methods accelerate the degradation of the insecticide and shorten their effectiveness over time. The washes in field conditions eliminate superficial amount of the insecticide on the fibers. From this moment, the LLIN lose their effectiveness if the distribution of the residual amount of the insecticide is effective from the inside to the outside of the fibers. The sustainability of the net concept on duration of action requires the control of the activation of the diffusion process in order to ensure regeneration of insecticides to the surface of the fibers after each wash. We must think of designing a LLIN use kit that will be made available to users.

5. Declaration of conflict of interest

The authors wish to declare that there is no conflict of interest.

Acknowledgement

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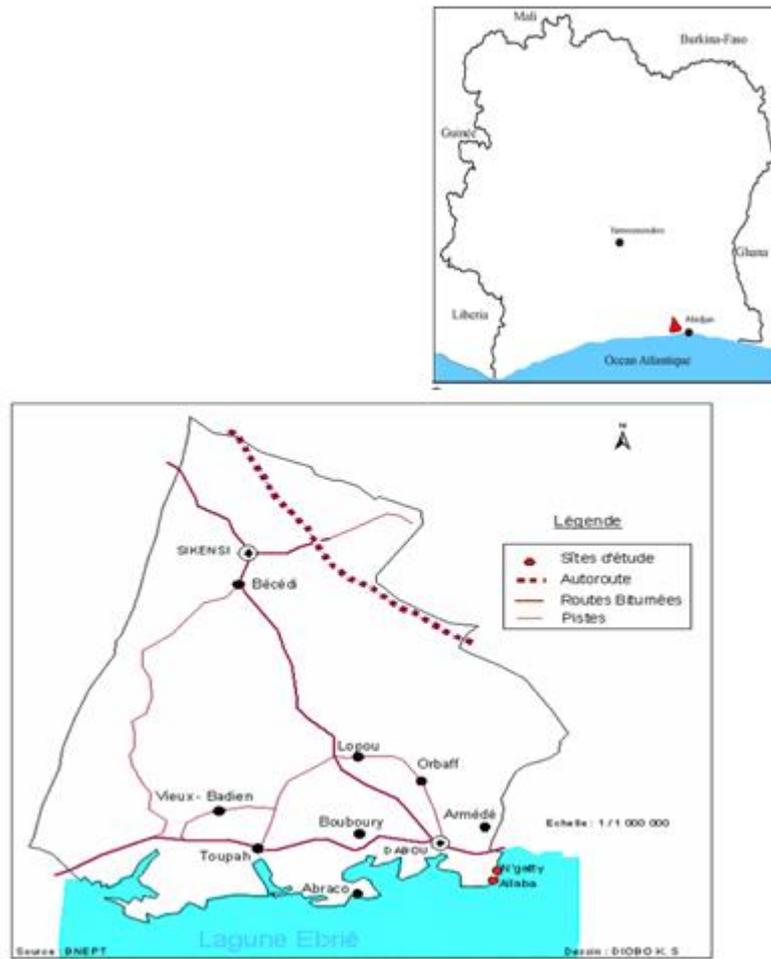


Figure 1: Map of Dabou department with the location of the study sites

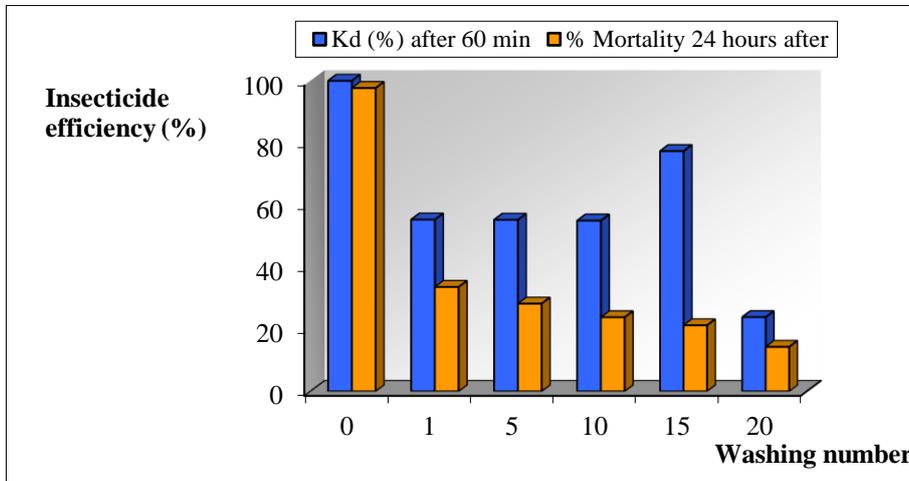


Figure 2: Evolution of the insecticide effectiveness based on the number washes of Olysetnet in use

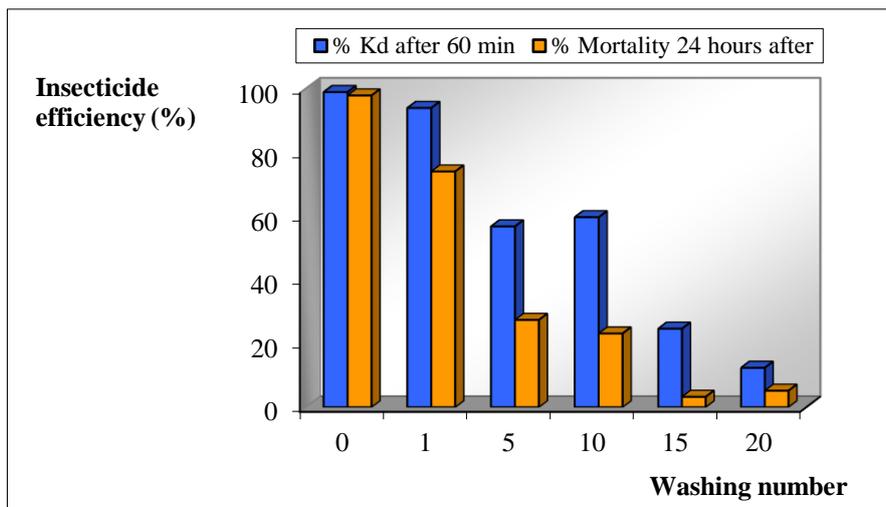


Figure 3: Evolution of the insecticidal efficacy as a function of number of washes of Permanet 2.0 nets in use

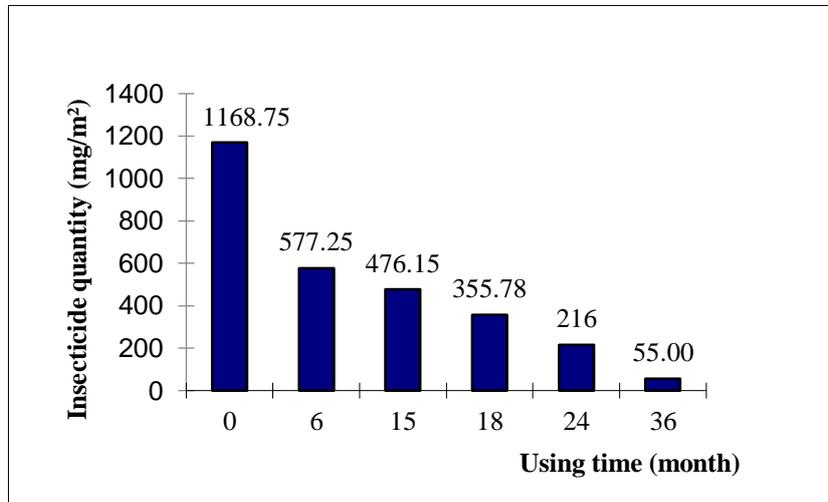


Figure 4: Evolution of the amount of permethrin in the Olysetnet fibers in use

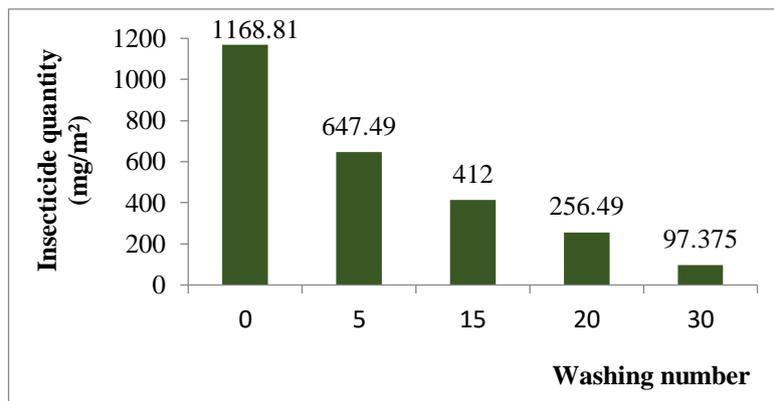


Figure 5: Evolution of the amount of permethrin in the Olyset based net on the number of washes

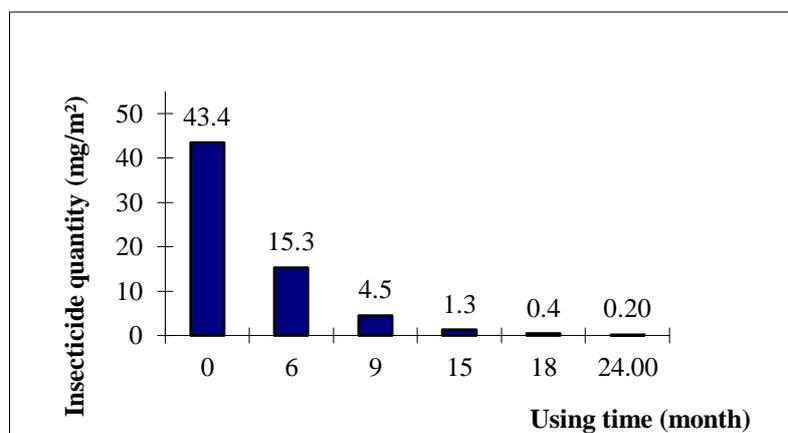


Figure 6: Evolution of the quantity of delta methrin in the fiber of LLIN Permanet 2.0 in use

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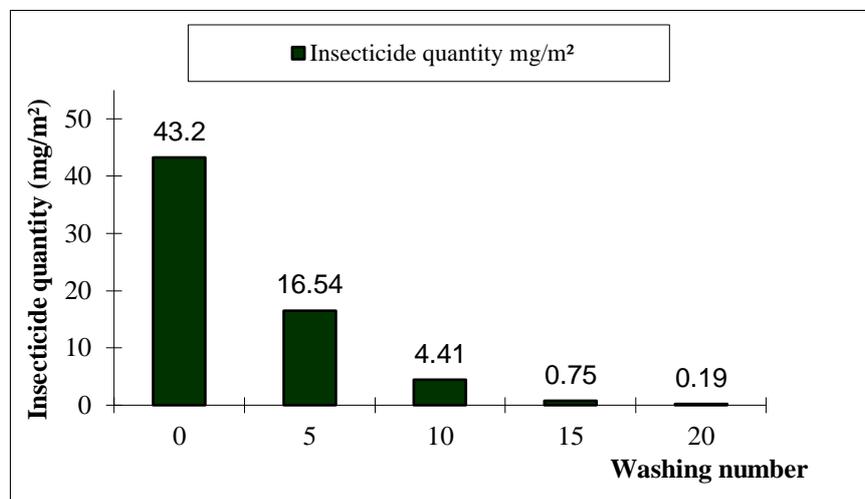


Figure 7: Evolution of the amount of deltamethrin in the Permanet 2.0 depending on the number of washes

Table I: Efficiency of Olyset 2.0 nets in use in N'gatty and Allaba

Uptime	Number of LLINs	Moustiquoes tested	Kd after 60 min of observation		Mortality observed after 24 hours	
			Effective (N)	Pourcentage (%)	Effective (N)	Pourcentage (%)
0 month	16	853	853	100,00	842	98,71 (94,6 - 100)
6 months	17	1126	670	61,42 (36,6 - 83,1)	390	35,44 (19,8 - 67,4)
15 months	16	827	601	72,67 (41,7 - 100)	347	41,96 (15 - 88,2)
18 months	15	626	452	67,73 (16,7 - 100)	181	25,72 (10 - 37,8)
24 months	12	648	148	20,70 (2 - 58)	29	3,40 (0 - 24,7)
30 months	13	677	126	18,70 (3,7 - 71,4)	39	5,80 (3,7 - 10,2)
36 months	11	578	21	3,64 (1,8 - 9)	21	3,64 (2 - 7,7)

Kd = knockdown; min = minutes; h = hour

Table II: Effectiveness of Permanet 2.0 nets in use in N'gatty and Allaba

Uptime	number of LLINs	mosquito estested	Kd after 60 min of observation		Mortality observed after 24 hours	
			effective (N)	Pourcentage (%)	effective (N)	Pourcentage (%)
0 month	13	765	765	100,00	760	99,35 (97,9 - 100)
3 months	7	405	362	89,38 (75 - 100)	298	73,58 (68,2 - 80)
6 months	7	366	175	47,81 (9,8 - 67,7)	128	34,97 (11,8 - 48,4)
9 months	7	602	386	64,12 (43 - 82,4)	141	23,42 (16,7 - 27,7)
15 months	11	558	195	34,95 (2 - 73,9)	24	4,30 (0 - 11,3)
18 months	12	636	83	13,05 (6 - 26,9)	34	5,35 (19 - 16,7)
24 months	12	634	41	6,53 (0 - 15,7)	47	3,49 (1,89 - 8)

Kd = knockdown; min = minutes; h = hour

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