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Probing the residual effects of Deltamethrin on different surfaces against malaria and dengue vector in Pakistan by designing laboratory model

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Abstract
Deltamethrin plays an effective role in suppressing the population of malaria and dengue vectors up to less danger level and it is also been used in indoor residual spraying. The residual activity of deltamethrin (K-othrine WP 5%) @ 25 mg/m2 was studied under laboratory conditions on different surfaces. Three sorbent surfaces i.e. cement, mud and plaster were prepared in pans. Wood and filter paper were cut in a situation that cone for carrying out bioassay test could be fitted on them easily. Four blocks were prepared of each surface, from which one block was not treated with insecticide to serve as control. The surfaces were attached to the wall and Deltamethrin WP 5% was sprayed at the dosage of 25mg/m^2 using standard Hudson pump at discharge rate 755-780ml/min. The bioassay test was carried out for evaluation of residual effect of Deltamethrin using WHO standard cones. Result of bioassay test on *An.stephensi* showed that filter paper surface have best residual capacity of Deltamethrin by presenting 67.65% mortality, followed by plaster, wood, cement and mud with % mortality (64.46%, 63.69%, 58.41% and 28.28%) respectively after 5 months of IRS application. Bioassay test on *Ae.aegypti* showed that filter paper surface have best residual activity of Deltamethrin by presenting 68.76% mortality, followed by plaster, wood, cement and mud with % mortality (64.62%, 59.15%, 57.26% and 40.22%) respectively after 5 months of IRS application. Whole study depicted that residual effect of Deltamethrin on different surfaces is variable. Furthermore, the study highlights proper knowledge of IRS and its management according to building material that may lead to best strategy, which might reduce vector population up to the desired level.

Keywords: Indoor Residual Spraying, Deltamethrin, Bioassay test, Dengue, Malaria

1. Introduction
Malaria vector mosquito *Anopheles* transmits malarial pathogen from one host to another host by its bite [1]. Globally there are almost 380 known species of *Anopheles*. In Pakistan there 24 reported species among them *An. culicifacies* and *An. stephensi* are two major malaria vectors [2].

Malaria is usually known as the disease of poverty. Annually about 300 to 500 million people suffer from malaria with 1-3 million deaths globally [3]. A half million cases of malaria occur annually in Pakistan. About fifty thousand deaths occurred due to malaria annually, among these infants, pregnant women and children are most affected [4].

Dengue is another emerging global health problem. Dengue is primarily an urban disease of the tropics, and the viruses that cause it are maintained in a cycle that involves humans and *Ae. Aegypti*, a domestic, day-biting mosquito that prefers to feed on human blood. Infection with a dengue virus serotype can produce a spectrum of clinical illness, ranging from a nonspecific viral syndrome to severe and fatal hemorrhagic disease [5].

Dengue is viral borne disease which is increasing in the world very fast. According to an estimate about 50 million dengue cases occur every year. There are almost 2.5 billion population is living those countries which come under the dengue endemic zones [6]. Pakistan first faced dengue epidemic in 1994 [7]. The worst dengue epidemic in Pakistan was in 2011, as dengue cases emerged in major cities. Health departments reported 22,560 cases which were confirmed and almost 363 deaths in 2012 [8].

The immense burden of vector borne diseases urges to device appropriate strategies to decrease disease burden by controlling disease vector. Among other strategies like chemical Control, biological control etc. Indoor Residual Spraying (IRS) is one of very good and efficient method for the control of different species of vector mosquitoes. The wide use of this

method has been seen in the Latin America and Asia. The effectiveness and efficiency of this process depends on the application method, resistance of vector, killing ability of insecticide, properly maintained equipment, sufficient training of persons and good financial resources [9].Global Malaria Action Plan (GMAP) emphasizes on the identification of appropriate and most effective strategy to control the vectors. This requires information and understanding the relation between the available tools and socio-economic factors. Houses are made of different types of walls. Each type of the wall has different residual effect when we apply an insecticide on it. Current study provided us the inferences about the effectiveness of IRS of Deltamethrin on different walls which may provide evidence based information for planning the effective mosquito control strategy in Pakistan.

2. Materials and Methods

2.1 Period of study

The study was completed in time duration of six months from January to June 2015.

2.2 Preparation of artificial surfaces

Three sorbent surfaces i.e. cement, mud and plaster were prepared in pans. The blocks were allowed to dry under laboratory conditions. The wood and filter paper are non-sorbent. So these surfaces were cut in a situation that cone for carrying out bioassay test could be fitted on them easily. All prepared samples were stored in wooden blocks in laboratory. Four blocks were prepared of each surface containing one cone on each tray, from which one block was untreated to serve as control. Three replicates of each treated surface were carried out. The filter paper (Whatman No.1) was attached to the sprayed surfaces normally and then removed and packed inside the kit for bioassay tests. The Deltamethrin WP 5% was used at the dosage of 25mg a.i./m2.

2.3 Mosquito Rearing

Adult susceptible colonies of *Ae. Aegypti* were maintained in insectary of MEDVC department of Health Services Academy Islamabad on 10% sugar solution and females were blood fed on live white rats. Larvae were reared in steel trays (24 x 36 x 6 cm) and fed on sterilized liver diet.

2.4 Mosquito species tested

An. stephensi and *Ae. Aegypti* were tested for cone bioassay test.

2.5 Residual spraying

Hudson® X-Pert compression sprayer which is recommended by WHO for IRS fitted with pressure gauge and HSS-8002 nozzle tips equipped with regulator set at 24–55 PSI pressure was used. The discharge rate of sprayer was measured as 755–780 ml/min. The duration for spray was set to spray 19m^2in one minute. The dried blocks were fixed on to the vertical surfaces of the wall. One sachet (125 g) of Deltamethrin was dissolved in 10 L of water into the tanks to obtain 25 mg a.i./m^2. After spraying, all the blocks were collected and stored in the box for further bioassay tests.

2.6 Bioassay Test

The bioassay test was carried out for evaluation of residual effect of Deltamethrin using WHO standard cones. The cones were fitted on each surface with scotch tape. About 5-7 sugar-fed insectary reared female mosquitoes were gently released into each cone at the vertical position. The mosquitoes were exposed for 30 min to the treated surfaces in three replicates. The same procedure was carried out for control. At the end of exposure time, the adults were transferred into the clean cup with cotton wool pad with 10% sugar solution and the mortality was recorded after 24 h recovery period.

Contact bioassay tests was carried out on Day 1, 5, 15, 30, 45, 60, 105, 120, 135 and 150 after application. Relative humidity and temperature of the laboratory were recorded during the bioassay experiments that were 75% and 27ºC, respectively.

2.7 Statistical analysis

Five replicates of the experiment were calculated for %mortality in treated and control cones. Percentage mortality was recorded after 24 hours recovery period on the standard form. The control mortality which lies "between" 5% to 20%, the average observed mortality was corrected by using Abbott's formula

$$\text{Abbott's formula} = \frac{\%\text{ test mortality}-\%\text{control mortality}}{100-\%\text{control mortality}} \times 100$$

The WHO recommended interpretation:

98-100%mortality indicates susceptibility

<80%mortality=resistant individuals present

80-97%mortality suggests the possibility of resistance that needs to be further confirmed [10].

3. Results

Result of bioassay test in Table 1 & 2 displayed filter paper best in terms of residual effective capacity and least shown by mud during 5months of application against *An. stephensi*.

Table 1: Results of %mortality on different surfaces with Deltamethrin at 25mga.i./m^2 under laboratory conditions against *An. Stephensi*

Day after application	%mortality(Mean±S.E)				
	Plaster	Mud	Cement	Wood	Filter Paper
1	88.6±1.32	81.6±5.38	100	74.31±5.91	87±4.1
5	100	96.44±2.34	100	92.18±3.69	91.5±3.88
15	94.54±3.13	91.52±3.8	100	89±4.5	98.33±1.79
30	98.33±3	97.5±2.24	100	100	95.55±3.13
Monthly Mean	95.36	91.76	100	88.89	93.12
45	98±2.16	59.61±7.22	100	68.33±7.5	88.18±6.24
60	83±5.64	78.85±6.88	100	85.78±5.7	95.83±4.35
Monthly Mean	91.5	68.23	100	77	91
105	79±5.93	50.45±6.62	82.9±5.76	80.41±6.1	91.55±4.46
120	77±6.31	55.35±6.21	78.79±4.33	71.7±6.8	83.39±5.47
Monthly Mean	80.68	53.25	89.52	75.43	86.9
135	52.3±5.65	28.28±7.1	76.66±8.1	62.62±6.66	69.2±7.4
150	52.25±7.52	--	52.26±7.41	64.76±7.68	66±9
Monthly Mean	64.46	28.28	58.41	63.69	67.65

Table 2: Result of %mortality on different surfaces with Deltamethrin at 25mg a.i./m2 against *An.stephensi* at different interval months

Month after spray	Surfaces				
	Filter Paper	Wood	Cement	Mud	Plaster
1	93.12	88.89	100	91.76	95.36
2	91	77	100	68.23	91.5
4	86.9	75.43	89.52	53.25	80.68
5	67.65	63.69	58.41	28.28	64.46

Result of bioassay test in Table 3 & 4 displayed filter paper best in terms of residual effective capacity and least shown by mud during 5 months of application against *Ae.aegypti*.

Table 3: Results of %mortality on different surfaces with Deltamethrin at 25mga.i./m^2 under laboratory conditions against *Ae. Aegypti*

Day after application	%mortality(Mean±S.E)				
	Plaster	Mud	Cement	Wood	Filter Paper
1	100	100	100	78.79±4.33	85.78±5.7
5	100	100	100	92.18±3.69	94.54±3.13
15	100	100	100	82.9±5.76	98.33±1.79
30	100	92.18±3.69	100	100	91.5±3.88
Monthly Mean	100	98	100	88.4	92.5
45	94.54±3.13	91.5±3.8	100	89±4.5	91.55±4.46
60	98.33±3	83±5.64	100	68.33±7.5	88.18±6.24
Monthly Mean	96.4	87	100	78	89
105	83±5.64	78.85±6.88	82.9±5.76	74.31±5.91	89±4.5
120	79±5.93	62.26±6.66	78.79±4.33	71.7±6.8	82.9±5.76
Monthly Mean	81	70.73	89.52	72	85.95
135	77±6.31	52.25±7.52	62.26±6.66	64.76±7.68	69.2±7.4
150	52.25±7.52	28.28±7.1	52.26±7.41	55.35±6.21	68.33±7.5
Monthly Mean	64.62	40.22	57.26	60	68.76

Table 4: Result of % mortality on different surfaces with Deltamethrin at 25mg a.i./m2 against *Ae. aegypti* at different interval months

Month after spray	Surfaces				
	Filter Paper	Wood	Cement	Mud	Plaster
1	92.5	88.4	100	98	100
2	89	78	100	87	96.4
4	85.95	72	89.52	70.73	81
5	68.76	60	57.26	40.22	64.62

4. Discussion

The results of our study were in accordance with previous investigations by different scientists. Rozilawati H *et al*. (2005) trailed residual effect of deltamethrin against the *Aedes* and found it effective up to almost 6 weeks. The trails also showed that both *Ae. Albopictus* and *Ae. Aegypti* were more susceptible on the house made of bricks and cement than wood [11]. Etang J *et al.* (2011) evaluated the efficacy of three different insecticides formulations on different surfaces. According to that study in the 26th week effectiveness of insecticides on mud surface ranged from 60 to 100% [12]. Mohammad A *et al.* (2011) find out the effectiveness of deltamethrin and evaluate the relationship between residual activity and persistence of it on different surfaces to control the malaria vectors. Deltamethrin showed its knockdown up to 120 days after its application on the walls used in the experiment [13]. Vatandoost H *et al*. (2009) conducted a trail in the laboratory to evaluate the residual effectiveness of deltamethrin. The bioassay performed on the *An. stephensi* showed the more than 70% mortality in 4 months on plaster surfaces, almost 77% mortality was recorded on mud surfaces in 2 months and 71.7% on wood surfaces in total of 4 months [14]. Kumar S *et al.* (2009) evaluated Deltamethrin and combinations of deltamethrin with PBO with the ratio of 1 and 5 for its efficacy against *Ae. aegypti* in another trial. The treatment of deltamethrin and its combinations showed 73 to 80% reduction in the population of mosquitoes [15].

5. Conclusion

Malaria and dengue fever are one of the most serious problems in different areas of Pakistan. Deltamethrin is widely used insecticide in Pakistan and is very effective against the mosquito species causing malaria and dengue fever if used properly and with complete information regarding its bio efficacy. From these results it was concluded that surfaces of filter paper and plaster are best in effectiveness against Deltamethrin even with the passage of time its residual effect remained best. Among all other tested surfaces, mud surface showed least performance. The whole study gave us fruitful findings that if we use insecticide for IRS on different building materials the residual effect according to building material should be kept in mind to effectively control disease vector population.

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