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ASSESSMENT OF AIR POLLUTANTS EMISSION FROM MOSQUITO COIL

Ayesha Akter[1] and Dr. Kazi ABM Mohiuddin[2]

[1] Department of Civil Engineering, Khulna University of Engineering & Technology, Bangladesh
[2] Professor, Department of Civil Engineering, Khulna University of Engineering & Technology, Bangladesh

ABSTRACT

Burning mosquito coils can generate smoke in the indoor environment containing pollutants of health concern. This study was performed to determine the concentration and emission rate of air pollutants from mosquito coil. Chamber experiment was performed to measure the concentration and emission rate of air pollutants. VOC of burning mosquito coil was measured from 71% to 83%. The atmospheric emission rate for all mosquito coil was ranged from 90 to 105 mg/h. The concentration of CO, SO_2, NOx were measured respectively from 279 to 373 µg/m3, from 1.1 to 2.6 µg/m3 and from 1.6 to 8.9 µg/m3. Average emission rates of CO, SO_2, and NOx were found as 320.2mg/h, 1.7 mg/h and 3.7 mg/h, respectively. The average concentration of $PM_{2.5}$ and PM_{10} was exceeded the indoor guideline limit. Formaldehyde and acrolein were the major carbonyl compounds identified in the coil smoke which was also exceeded the indoor guideline limit.

Keywords: *Indoor air pollution; Mosquito coil; Chamber experiment; Emission rate*

1. INTRODUCTION

Mosquito coil is generally used for mosquito repellent and insecticide in the tropical and subtropical areas (Li et al., 1993). The combustion of mosquito coils could generate carbon monoxide (CO), sulfur di-oxide (SO_2), nitrogen oxides (NOx), particulate matter ($PM_{2.5}$, PM_{10}), carbonyl compounds, volatile organic compounds etc. Liu et al. (2003) also indicated that burning one mosquito coil mosquito coil would release the same amount of $PM_{2.5}$ mass as burning 75–137 cigarettes. The major active ingredients of the mosquito coil are pyrethrins, accounting for about 0.3–0.4% of coil mass (Lukwa and Chandiwana 1998). Pyrethrins are major active ingredients. Pyrethrum is a natural extract from the chrysanthemum flower. When a mosquito coil is burned, the insecticides evaporate with the smoke, which prevents the mosquito from entering the room. Pyrethrins are of low chronic toxicity to humans and low reproductive toxicity in animals, although headache, nausea, and dizziness were observed in male sprayers exposed to 0.01–1.98 µg/m3 pyrethrins for 0.5–5 hr. (Zhang et al. 1991).

Despite the fact that mosquito coil smoke may have many potential adverse health effects, large populations in developing countries still use mosquito coils in their daily lives. In previous studies of various aspects of mosquito coil smoke, emissions of irritating and carcinogenic compounds and other pollutants have not been quantified, which precludes the use of emission rate data to predict pollutant concentrations in households and to quantify health risks. Data are also lacking for comparing emissions from different types of mosquito coils. To make informative recommendations to consumers as to which types of mosquito coil have lower emissions of health-damaging pollutants, it is necessary to perform tests of coil emissions in a systemic manner. The objectives of this study were to determine the physical properties of mosquito coil, concentration and emission rate of air pollutants.

2. MATERIALS AND METHODS

Five types of mosquito coils were tested in this study. The material selection was based on production quantity of the materials and extent of use in a home. The appearances (shape, diameter and color) of these mosquito coils are quite similar.

2.1 Proximate Analysis

Five brands of mosquito coils were taken. Then smashed the mosquito coil with the help of hammer. Then collect the weight of powdered mosquito coil of each sample was taken and kept it in an oven at a temperature of 100˚C for 24 hours. The samples were then cooled and reweighted. Then moisture content was determined. The previous samples were taken which were used for moisture determination. Then the samples were placed into a furnace at a temperature 550˚C. After half an hour the samples were taken out and reweighted. Then the volatile organic compound was calculated.

2.2 Atmospheric Emission Rate

The weight of the sample was taken before burning. Then the mosquito coil was ignited until the coil was extinguished. The weight of ash was determined after burning of the mosquito coil. Then the atmospheric emission rate was calculated by following equation:

$$Emission\ Rate = \frac{A - B}{A \times T}$$

Where,
A= Weight of Coil before burning
B= Weight of Coil after burning
T= Time of Burning

2.3 Chamber Experiment

A chamber using plastic box with two small openings was taken to conduct chamber experiment. The ignited mosquito coil is placed into the chamber for 5 minutes. Then air quality analyzer was placed in the chamber. Three boxes are used in this experiment. Then using that data the concentration and emission rate were determined for a typical room (4.3m×6.1m×3m with 79.31m^3 effective volume). 30% air exchange rate is considered here.

2.4 Emission Estimation

By using the value of emission factor of $PM_{2.5}$ and PM_{10} from Lee et al. (2006) the concentration and the emission rate was estimated for $PM_{2.5}$ and PM_{10} for the same room. By using the maximum concentration of formaldehyde, acetaldehyde, acetone, acrolein and propionaldehyde from Lee et al. (2006) the concentration of carbonyl compounds were estimated for the same room of volume 79.31 m^3.

3. ILLUSTRATIONS

3.1 Proximate Analysis

The proximate analysis comprises of moisture content, volatile organic content and ash percentage of mosquito coil. Experimental result on proximate analysis is shown below Table 1. Here, MC (%) ranged from 12(%) to 14%. For MC3, MC4 and MC5 the percentage of moisture contents were same. For MC1 and MC2 the MC (%) are close enough. The VOC of burning mosquito coil was measured from 71% to 83%. Percentage of ash is high for MC1. The overall proximate results are same for MC4 and MC5.

Table 1: Experimental result on proximate analysis

Sample ID	MC (%)	VOC (%)	Ash (%)
MC1	12	71	17
MC2	14	80.5	5
MC3	13	77	9.5
MC4	13	83	4
MC5	13	83	4

3.2 Atmospheric Emission Rate Estimation

Atmospheric emission rate of mosquito coil for five different brands were shown in Table 2. Here, the atmospheric emission rate for MC2 to MC4 are close enough and ranged from 90.3 to 105 mg/g-hr. But for the sample MC1 the rate of emission is 78.38 mg/g-hr. MC1 is the product of china.

Table 2: Atmospheric emission rate calculation

Sample ID	Amount of Emission (%)	Emission Rate (mg/g-hr)
MC1	58	78.38
MC2	62	100.5
MC3	67	90.3
MC4	81	105
MC5	87	103.8

3.3 Concentration and Emission Rate of Air Pollutants

Chamber experiment is shown in the following figures (1, 2, 3, and 4)

Figure 1: Plastic boxes with two small Openings

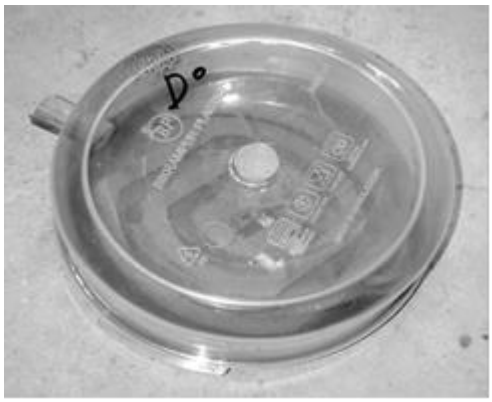

Figure 2: Ignited mosquito coil placed into chamber

Figure 3: Air quality analyzer

Figure 4: Placing of air quality analyzer

3.3.1 Concentration of criteria gas pollutants (CO, SO_2, NO_x, NO)

From chamber experiment the data of carbon monoxide (CO), Sulfur dioxide (SO_2), nitrogen oxides (NOx) was collected in mg/m^3 by air quality analyzer. The concentration of tested mosquito coils for 4 criteria gas pollutants (CO, SO_2, NOx, NO) are summarized in Table 3.

The CO concentration was ranged from 279 to 373 µg/m^3. The highest concentration of CO was measured for MC4 and the value is 373 µg/m^3. The permissible limit of CO is 10000 µg/m^3. So the average concentration of CO measured from the chamber experiment is under the permissible limit. The concentration of CO for five samples. Average, minimum, maximum and standard deviation of concentration of CO are respectively 336 µg/m^3, 279 µg/m^3, 373 µg/m^3 and 36.4 µg/m^3.

Table 3: Concentration of Air Pollutants for typical indoor environment

SAMPLE ID	CO (µg/m^3)	SO_2 (µg/m^3)	NO_x (µg/m^3)	NO (µg/m^3)
MC1	361	1.1	1.6	1.2
MC2	279	1.7	8.9	5.4
MC3	338	2.6	5	3.1
MC4	373	1.6	2	1.6
MC5	329	1.6	1.7	1.2
AVERAGE	336	1.7	3.8	2.5
SD	36.4	0.5	3.2	1.8

The SO_2 concentration were so close for tested mosquito coils. It ranged from 1.1 to 2.6 µg/m^3. For MC3 sample the concentration of SO_2 was the highest and the value was 2.6 µg/m^3. The standard deviation was found 0.5. The permissible limit for SO_2 given by WHO is 125 µg/m^3 for 24 hours.

MC2 had the highest concentration of NO and NOx and which were respectively 8.9 µg/m^3 and 5.5 µg/m^3. The NO_x concentration was ranged from 1.6 to 8.9 µg/m^3.The average concentration of NO_x was found 3.8 µg/m^3. The permissible limit of NO_x is 0–1000 ppb. So the concentration of NO_x is under limit.

3.3.2 Emission rate of criteria gas pollutants (CO, SO_2, NOx, NO)

The maximum, average, standard deviation and minimum emission rate of the air pollutants emitted from five mosquito coils are shown in Table 4. Here, average rate of emission is 320.2 mg/h. MC1 emit the maximum rate of CO. The CO emission rate ranged from 266 20 355 mg/h.

The SO_2 emission rates were so close for tested mosquito coils. The average SO_2 emission rate is 1.7 mg/h and ranged from 1.06 to 2.47 mg/h. The NOx and NO emission rates varied among tested mosquito coils. The highest emission rate occurred on MC2 (respectively 8.46 mg/h and 5.17 mg/h), which was nearly six times of that of MC1 (1.53 mg/h).

Table 4: Emission rate of air pollutants for typical indoor environment

SAMPLE ID	CO mg/h	SO_2 mg/h	NOx mg/h	NO mg/h
MC1	344	1.06	1.53	1.18
MC2	266	1.65	8.46	5.17
MC3	322	2.47	4.76	3
MC4	355	1.59	1.94	1.59
MC5	314	1.59	1.59	1.23
AVERAGE	320.2	1.7	3.7	2.4
SD	34.5	0.5	3	1.7

3.3.3 Concentration and emission rate of particulate matter ($PM_{2.5}$, PM_{10})

By using the emission factor the concentration and emission rate of particulate matter were estimated. Table 5 shows the concentration and emission rate of particulate matter ($PM_{2.5}$, PM_{10}).

Table 5: Concentration and emission rate of particulate matter ($PM_{2.5}$, PM_{10})

SAMPLE ID	Emission rate of $PM_{2.5}$ mg/h	Emission rate of PM_{10} mg/h	Concentration of $PM_{2.5}$ $\mu g/m^3$	Concentration of PM_{10} $\mu g/m^3$
MC1	62	57	40.5	180
MC2	91	84	50	220
MC3	98	91	60	250
MC4	118	110	80	270
MC5	104	96	77	190
AVERAGE	95	88	62	222

Here, the emission rate ranged from 62 to 118 mg/h for $PM_{2.5}$ and from 57 to 110 mg/h PM_{10}. MC4 had both the highest emission rate for $PM_{2.5}$ and PM_{10}. Liu et al. (2003) found that the ultrafine and fine particles dominated the counts of particles emitted by coil combustion, and the emission factor of $PM_{2.5}$ were from 32.7 to 70.1 mg/h, which was close to the findings in this study. In table 5 the concentration ranged from 40.5 to 80 mg/h for $PM_{2.5}$ and from 180 to 270 mg/h for PM_{10}. MC4 had both the highest concentration for $PM_{2.5}$ and PM_{10}. The permissible concentration of $PM_{2.5}$ and PM_{10} are respectively 40 $\mu g/m^3$ and 150 $\mu g/m^3$. From Table 3.5 the average concentration of $PM_{2.5}$ and PM_{10} were 62 and 222 $\mu g/m^3$ which crossed the permissible limit.

3.3.4 Concentration of Carbonyl Compounds

Table 6 illustrates the concentrations of 5 carbonyl compounds identified for five tested mosquito coils. From this table the average concentrations of formaldehyde, acetaldehyde, propinaldehyde and acrolein were respectively 299 $\mu g/m^3$, 275 $\mu g/m^3$, 77 $\mu g/m^3$, 96 $\mu g/m^3$ and 120 $\mu g/m^3$. The minimum permissible limit of concentration for formaldehyde, acetaldehyde and acrolein were respectively 120 $\mu g/m^3$, 9000 $\mu g/m^3$ and 50 $\mu g/m^3$. So the average concentrations of formaldehyde and acrolein exceeded the permissible limit. So it is called that formaldehyde and acrolein were the major carbonyl compounds.

Table 6: Concentration of carbonyl compounds

Sample ID	Formaldehyde (µg/m^3)	Acetaldehyde (µg/m^3)	Acetone (µg/m^3)	Propinaldehyde (µg/m^3)	Acrolein (µg/m^3)
MC1	298	274	76	95	119
MC2	250	230	64	80	100
MC3	298	274	76	95	119
MC4	310	285	79	99	124
MC5	338.5	311	87	108	135
Average	299	275	77	96	120

4. CONCLUSIONS

The study revealed that VOC of burning mosquito coil was measured from 71% to 83%. The atmospheric emission rate for all mosquito coil was ranged from 90 to 105 mg/h. The concentration of CO (279 to 373 µg/m3), SO2 (1.1 to 2.6 µg/m3), NOx (1.1 to 2.6 µg/m3) were measured using chamber experiment. Average emission rates of CO, SO2, and NOx were found 320.2mg/h, 1.7 mg/h and 3.7 mg/h, respectively. The average concentration of PM2.5 (62 µg/m3) and PM10 (222 µg/m3) were exceeded the indoor permissible limit. The concentration of formaldehyde (299 µg/m3) and acrolein (120 µg/m3) were estimated which also exceed the indoor guideline value. The research can be continued by analyzing the health risk using the air pollutants data.

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