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Mosquito Coils: A Source of Elemental Pollution

Noorddin Ibrahim

Centre for Foundation Studies in Science, University of Malaya, 59100 Kuala Lumpur, Malaysia

In Malaysia and other tropical countries, mosquitoes are known to spread diseases like malaria and dengue fever. A common way of controlling mosquitoes in domestic households is to use insect repellants such as mosquito coils. These mosquito coils when burned will continuously emit smoke which prevents the mosquitoes from infesting the nearby area. This mode of prevention has been in use for decades and has proven to be an effective mosquito repellant. However, no known studies have been carried out to ascertain the elemental contents of these mosquito coils. The ashes from the burned coils may contain toxic trace elements which when accidentally inhaled into the body will cause serious damage to the living tissues (Bridford & Stein 1979; Byers 1965).

The present study was undertaken to determine the elemental contents of mosquito coils and their ashes using the method of instrumental neutron activation analysis (INAA). This method has been widely used for multielemental analysis. It is non-destructive in nature and as such the problem of chemical contamination is minimised.

MATERIALS AND METHODS

Representative samples of the most common brand of mosquito coils were purchased from the local supermarket. Ten mosquito coils were picked at random from a box of thirty and were then weighed.The average weight of each coil is 12.3 gm. Each coil has an outermost diameter of 10.5 cm. From these ten coils, five coils were finely ground inside a precleaned porcelain dish. The homogenized samples were then placed inside five separate polyethylene vials (2/5 dram). The remaining five coils were lit up and left to burn naturally overnight. On average it took about

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eight hours for each coil to finish burning. The ashes (average 0.6 gm per coil) were then collected and placed in another set of five separate vials. Special care was taken to avoid any contamination from foreign particles. In total we have ten filled vials ready to be irradiated. The net weight of the content in each vial is approximately between 200-500 milligrams. The National Bureau of Standards Coal Ash (SRM 1632a) was used as the multielement comparing standard. A duplicate of the standards were used, each having a net weight of approximately 200 milligrams. All vials were then heat sealed and placed inside an aluminium cylindrical container before being transferred into the reactor.

The reactor used to irradiate the samples is the Atomic Energy Unit research reactor TRIGA MKII with thermal neutron flux of 4 x 10^{12} n/cm^2/sec. The irradiation time taken was ten hours. After irradiation, the aluminium container was transferred out from the reactor core and left to cool for a certain period of time. This cooling procedure was undertaken to enable the background radiations to die off. The activities of the samples, ashes and standards were then measured with a horizontal Hypergermanium detector which is coupled to a 4096 channel pulse height analyser. In this study the counting system used has an energy resolution of 1.90 keV (FWHM) for the 1332 keV gamma ray of ^{60}Co. The presence of trace elements in any given sample are deduced from the detection of their respective radioisotopes. Each of the radioisotope has a fixed lifetime. For example, in order to detect radioisotopes with medium half-life, the activities of the samples were measured after one week of cooling time while a decay time of one month was allowed for the detection of long-lived radioisotopes. To calculate the concentration level of each element we used the method of comparison. Table 1 shows the results of our analysis on the NBS 1632a. Our results are in agreement with the certified values as well as the values obtained by Germini et. al (1980).

RESULTS AND DISCUSSION

The trace elemental contents of the mosquito coils and their ashes were determined by the method of Instrumental Neutron Activation Analysis (INAA). We have selected the most commonly used brand of mosquito coils available in Malaysia.

The elements and their average level of concentration (ppm) are shown in Table 2. The second column shows the reference gamma-ray photopeak energy (keV) used for the identification of radionuclides associated with the elements (Lederer and Shirley, 1978).

Table 1. Comparison of concentration of elements (ppm) in NBS Coal Ash 1632a.

Element	Our values	Certified values	Germini et.al (1980)
Ba	110	-	122
Eu	0.60	0.54	0.55
Sm	2.3	-	2.80
As	12	9.3	10
Fe	1.14	1.11	1.16
Cr	31	34.4	34
Co	6.6	6.8	6.5
Th	4.2	4.5	4.8
U	1.24	1.28	1.21
Sb	0.80	0.58	0.60
La	18.2	-	18.0
Sc	7.0	6.3	6.8
Zn	31	28	-

In the last column, the percentage conversion of these elements into smoke are tabulated. These figures are calculated from the percentage of ashes per coil and the concentration of elements in the ashes. They approximately depict the amount of elements which are exposed to the users.

The results of our analysis have shown that the method of INAA is accurate in determining the concentration levels of various elements. As indicated in table 2, the sensitivity of this method can reach up to level parts per billion. For example, element Au has a concentration level of 4 ppb in coil and 7 ppb in ash. In addition, by using this method of analysis many elements can be determined simultaneously. A total of twenty one elements have been detected in both the coils and their ashes. The highest concentration of observed is that of barium with concentration of 28.3 ppm in coil and 706 ppm in ash. Wood (1974) classified

Table 2. Concentration (ppm) of trace elements in mosquito coils and their ashes.

Element	Ref. Peak (keV)	Concentration (ppm) Sample	Concentration (ppm) Ash	% in smoke
As	559.6	0.44 ± 0.09	7.94 ± 0.48	12.6
Au	411.9	0.004 ± 0.002	0.007 ± 0.004	91.9
Ba	497.0	28.3 ± 10.8	706 ± 97	-
Br	554.9	6.55 ± 0.5	72.9 ± 5.5	46.6
Ce	145.4	2.21 ± 0.38	50.3 ± 7.2	-
Co	1332.4	0.43 ± 0.07	6.9 ± 0.4	23.3
Cr	320.4	2.56 ± 0.48	55.2 ± 3.8	-
Cs	796.6	0.39 ± 0.10	6.4 ± 1.3	19.7
Eu	1409.0	0.06 ± 0.01	-	-
Fe	1099.8	0.07 ± 0.01	1.50 ± 0.05	4.5
Hf	480.6	0.34 ± 0.04	4.99 ± 0.39	30.0
La	1596.5	1.58 ± 0.20	31.9 ± 3.5	2.8
Lu	208.8	0.027 ± 0.007	0.50 ± 0.11	11.6
Rb	1077.3	28.1 ± 3.4	471 ± 27	19.5
Sb	564.6	0.094 ± 0.018	1.33 ± 0.22	32.1
Sc	889.9	0.22 ± 0.02	4.90 ± 0.42	-
Sm	103.3	0.27 ± 0.03	5.57 ± 0.02	1.0
Th	312.3	0.99 ± 0.06	21.4 ± 0.9	-
U	229.4	0.24 ± 0.05	5.22 ± 0.55	-
Yb	397.0	0.11 ± 0.02	2.45 ± 0.23	-
Zn	1116.0	19.1 ± 3.5	244 ± 28	-

Table 3. The comparison of concentration of elements (ppm) obtained by INAA in mosquito coil ashes and cigarette ashes.

Element	Concentration (ppm)	
	Coil ashes	Cigarette ashes
Ba	706	51
Br	73	455
Ce		8.9
Co	6.9	1.7
Cr	55.2	10.1
Cs	6.4	0.57
Eu	-	0.10
Fe	1.5	0.14
Hf	4.99	0.29
La	31.9	7.7
Rb	471	105
Sc	4.9	0.38
Th	21.4	0.78
Zn	244	262
Lu	0.50	0.05
Sm	5.57	0.43

element Ba as toxic but very insoluble. Element Au has the lowest concentration (4 ppb in coil and 7 ppb in ash).

Several important observations are deduced from our study. Firstly, the most common brand of mosquito coils available in Malaysia contain trace elements which are toxic. The concentration of some of these elements are high. Our findings have shown the existence of Arsenic (As) with concentration of 0.44 ppm in coil and 7.94 ppm in the ashes. The percentage conversion of this element from coils into smoke is approximately 12.6%. The element bromine which may exist as organo bromide has a concentration of 6.55 ppm in coil and 72.9 ppm in ash. Elements such as Co and Fe have a tendency to form toxic metal carbonyl (Standen, 1964). They may exist partially as complexes in which upon combustion can convert to metal carbonyl. Another element with high concentration is rubidium (Rb) with concentration of 28.1 ppm in coil and 471 ppm in ash. However, Rb is classified as a non-critical environmental pollutant (Wood, 1974). The presence of lanthanides (Ce, Eu and La) have also been observed from our analysis.

The second important observation is that the ashes also contain toxic elements of considerable concentration. Five elements (Br, Ce, Cr, La and Th) were observed to have concentration levels greater than 20 ppm. As a comparison, table 3 shows concentration levels of elements observed in mosquito coil ashes and cigarette ashes (Ibrahim et.al. 1987). With the exception of elements Br and Zn, the concentration of other elements were found to be higher in coil ashes.

Finally, we observe that some amount of these trace elements are released into the air together with the smoke.This again may be harmful when inhaled.

Our study revealed that mosquito coils can contribute to elemental pollution in the air. By burning mosquito coils the surrounding area is polluted with toxic trace elements. Special care should be taken by the users to avoid direct inhalation of either the smoke or the ashes of mosquito coils.

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