

Cadmium in Smoke Particulates of Regular and Filter Cigarettes Containing Low and High Cadmium Concentrations

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Appreciable concentrations of cadmium are absorbed from soils by tobacco (Nadkarni 1974). Considerable research has been conducted on the deleterious effects of cadmium on the respiratory system during smoking (Gutenmann et al. 1982). Since the provisional dietary intake of cadmium (FAO/WHO 1972) takes smoking into account, any agricultural practices which would increase cadmium in tobacco are of concern.

Sewage sludges, especially of municipal origin, contain appreciable concentrations of cadmium (Furr et al. 1976; Mumma et al. 1984). Tobacco grown on soil amended with such sludges can absorb high concentrations of the metal which results in greatly elevated quantities of cadmium in mainstream particulates when such tobaccos are smoked as nonfilter cigarettes (Gutenmann et al. 1982).

It is presently common practice for smokers to prepare their own filter or nonfilter cigarettes and reasonably-priced kits of various manufacturers are marketed for such cigarette fabrication. It was of interest to determine the extent to which filters in such cigarettes containing tobacco of low or high cadmium content would reduce cadmium in the mainstream smoke particulates.

In the work reported, filter and nonfilter cigarettes were prepared from high-cadmium tobacco grown on a municipal sludge-amended soil or a low-cadmium tobacco grown on untreated soil alone. These were smoked by machine to determine the effectiveness of the cigarette filters in possibly reducing the quantities of cadmium in the mainstream smoke particulates.

MATERIALS AND METHODS

Virginia 115 tobacco (*Nicotiana tabacum*) was grown in the field on a soil to which 224 dry metric tons per hectare of a municipal sludge from Syracuse, New York was applied and on the untreated (control) soil. The details of its culture and curing were described earlier (Gutenmann et al. 1982). Fifty cigarettes containing filters and fifty without filters were prepared each

from the sludge-grown and soil-grown tobaccos using a Laredo Filter Cigarette Making Kit (Brown and Williamson Tobacco Corp., Louisville, KY). Both filter and nonfilter cigarettes contained $0.75 \text{ g} \pm 10 \text{ mg}$ of tobacco but the filter cigarettes, 85 mm in length, were 20 mm longer since they included the 20 mm length of cellulose filter.

The cigarettes were placed in a glycerol-water humidity chamber (25°C, 60% relative humidity) for 14 days and smoked back to a point 55 mm from the original tip of the cigarette in a smoking machine using standard procedures (Pillsbury et al. 1969). Since the cigarettes were fabricated experimentally, they did not burn quite as evenly as commercial cigarettes. The particulate material of the mainstream smoke of five cigarettes was trapped on a single Cambridge filter. Only the mainstream smoke generated by drawing one 35-ml puff (lasting 2 sec.) once per minute was filtered and scrubbed. A new Cambridge filter was used for each set of five cigarettes. The Cambridge filters were wet-ashed using nitric, sulfuric and perchloric acids. The acid digests were analyzed for cadmium by conventional stripping voltammetry.

RESULTS AND DISCUSSION

The results of analyses of cadmium in the tobaccos and growth media constituents are listed in Table 1. The cadmium content of the sludge used in this study was typical of that in many municipal sludges (Mumma et al. 1984). The cadmium content of the soil-grown tobacco corresponded to the upper range of that reported for commercial cigarette tobaccos by Westcott and Spincer (1974). They reported cadmium levels of 0.5 to 3.5 ppm with concentrations being independent of the country of origin or the curing process. The high concentration of cadmium in the sludge-grown tobacco dramatically indicates the facile absorption of this element by tobacco even at the soil pH of 6.4 in the study which should diminish the mobility of cadmium.

Table 1. Concentration (dry wt) of cadmium in tobaccos, soil and sludge.

Sample	Cadmium (ppm)
Tobacco laminae (soil)	3.61
Tobacco laminae (sludge)	62.9
Syracuse sludge	84.0
Manure	0.6
Soil	1.3

The quantities of cadmium in the mainstream particulates of the cigarette smoke are listed in Table 2. The data indicate that cadmium was diminished in mainstream smoke particulates as a result of incorporation of filters during cigarette fabrication. The reduction was significant ($p < 0.05$) for the soil grown cigarettes but not in those representing the sludge treatment.

Table 2. Cadmium in mainstream particulates of tobacco smoke.

Treatment	Cadmium ^a ng/cigarette
Sludge unfiltered	3850 ± 231 ^x
Sludge filtered	3600 ± 130 ^x
Soil unfiltered	153.0 ± 13.8 ^x
Soil filtered	110.8 ± 7.0 ^y

^aAverage ± standard error of 50 cigarettes in each treatment smoked in ten successive groups of five cigarettes simultaneously; dissimilar letter superscripts between respective treatment means indicate significant differences ($p < 0.05$).

The reduction of cadmium in mainstream smoke by the filters incorporated in commercially prepared cigarettes has been reported to be much greater than found in this study (Westcott and Spincer 1974; Perinelli and Carugno 1978) and is a function of the composition of the filter and cigarette construction. The recent production of ventilated cigarettes also lowers cadmium in mainstream smoke (Scherer and Barkemeyer 1983). This study indicates that the extent of reduction of cadmium in mainstream cigarette smoke by filters of commercially prepared filter cigarettes may not be able to be duplicated when filter cigarettes are prepared individually using manually-operated fabricating devices.

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