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CSC Smudging Toxicity: Testing

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Executive Summary

National Research Council (NRC) was approached by Correctional Services Canada (CSC) to evaluate the potential health hazard induced by inmates' smudging activities to inmates as well as correctional facility staff. The study included three tasks. Task 1 encompasses a literature review to investigate the typical composition of smudging materials, probable combustion effluents and their yields. Task 2 assesses potential impacts from exposure to smudging effluents.

The findings from Tasks 1 and 2 were reported to CSC in a previous report[1]. These findings demonstrated that an insufficient amount of information exists particularly on yields of effluents produced during smudging. Therefore, Task 3 was planned to obtain the chemical effluent and smoke particulate matter data from smudging.

This report presents the findings from Task 3, where comprehensive evaluation of the hazards associated with smudging was conducted by testing four common smudging materials; black sage, juniper, tobacco, and white sage; in two testing facilities:

1) Tube furnace connected to a Fourier-transform infrared spectroscopy (FTIR) to detect and quantify the chemical combustion effluents
2) Testing room equipped with a Nanozen particle monitor to measure the particulate matter (PM) resulting from smudging.

The combustion effluents and PM data from the testing were analyzed to estimate concentrations likely to be present in an inmate cell and their health effects. Finally, combustion effluent hazard assessment and recommendations were provided.

[1] Y. Ko, "CSC Smudging Toxicity : Literature Review," A1-017894.1, 2021.

1 Introduction

Smudging is a traditional ceremony for purifying or cleansing the soul of negative thoughts of a person or place. It is a common practice by some of the indigenous peoples of the Americas. Smudging activities are conducted in correctional facilities by inmates as part of a cultural ritual. Smudging is defined in Correctional Service Canada (CSC) Commissioner's Directive (CD) 702 [1] as the act of burning traditional medicines (e.g. sweet grass, sage, cedar or tobacco) to pray and purify oneself or physical space. Various types of tobacco including commercial tobacco are also counted in CSC Standing Order (SO) 259: Millhaven Institution-Accommodation of Spiritual Practices [2].

The potential impacts of smudging mainly on the performance of detection systems in correctional facilities were studied. In 2018, NRC tested three selected smudging materials in a test room to investigate the amount of smoke generated from the smudging materials and the response of the detectors to the smudging. It was found that the smudging sources produced large amounts of smoke although a limited amount of the smudging sources was burned using a small heat source (hot plate). In addition, the level of smoke obscuration measured from the smudging sources was significantly higher than that resulted from the same amount of other smouldering sources (e.g. pieces of blankets, bed sheets and mattresses) tested in the room [3].

With regard to the potential health effect, the impacts of smudging on inmates or correctional facility staff have not been clearly studied while smudging produces various chemicals and smoke. The NRC (National Research Council Canada) was approached by Correctional Services Canada (CSC) to assess the potential health hazard resulting from smudging activities. In 2021, NRC conducted Task 1: literature review to investigate the typical composition of smudging materials, probable combustion effluents and their yields; and Task 2: exposure assessment for potential impacts from exposure to smudging effluents. The details of Task 1 and Task 2 are provided in the report to CSC [4] , which concluded that an insufficient amount of information exists particularly on yields of effluents produced during smudging.

Therefore, Task 3 was planned for further testing and data analysis to more comprehensively evaluate the hazards associated with smudging. This included:

- Tube furnace testing of four common smudging materials for measurement of combustion toxicants using Fourier-transform infrared spectroscopy (FTIR).
- Room testing of four common smudging materials for measurement of PM using a Nanozen particle monitor.
- Analyses and assessment of combustion effluent data.

The tube furnace and room tests were conducted by NRC, and the test data were analyzed in collaboration with FireTox, LLC. This report presents the findings from these tests and analyses. Detailed toxicity analyses are provided in Supplement A. Toxicity Analysis Report from FireTox, LLC..

In addition, the conclusions of our study are compared against the on-site data measured in CSC centers in Dorchester- New Brunswick [5] and Saskatoon [6]. Both studies conducted valuable on-site measurements during smudging ceremonies that were carried out in specified smudging rooms. The study from New Brunswick just measured gaseous emissions (Nicotine, aldehydes, VOC's) while that from Saskatoon measured gaseous emissions and PM.

1.1 Objectives and Scope

The purpose of the testing conducted in this study was to determine the combustions effluents resulting from smudging and assess the potential health effects of exposure to these smudging effluents. Moreover, recommendations to mitigate the risk were provided based on the testing results.

2 Testing

Four common smudging materials; black sage, white sage, juniper and tobacco were tested in 2 different testing facilities to determine their combustion effluents. The first facility was a tube furnace connected to a Fourier-transform infrared spectroscopy (FTIR) to quantify the gaseous effluents. The second facility was a testing room with a particle counter (Nanozen) to quantify the particulate matter (PM) emitted during smudging activities. PM was measured in the room test rather than the tube furnace because PM concentration in the tube furnace test exceeded the measurement capabilities of the Nanozen. The following subsections describe each facility and the testing procedures.

2.1 Tube furnace test

Toxic product yields are dependent mainly on materials and fire conditions. Thus, tube furnace is widely used in characterizing toxic products since the device allows replicating the generation of toxic products under different combustion conditions. The tube furnace simulates a range of combustion conditions; stage 1b: oxidative pyrolysis from externally applied radiation, stage 2: well ventilated flaming, stage 3a: small, vitiated fire in closed or poorly ventilated compartments, and stage 3b: post-flashover fires in open compartments. In this work, the tube furnace was used to determine the effluents from the combustion of the four smudging materials under two conditions; oxidative pyrolysis and small vitiated fire conditions. Those conditions were chosen since they are the main stages that occur during smudging. Each test was repeated twice.

Figure 1 shows a photo of the tube furnace testing facility. It consisted of;

1- A furnace with a controller to adjust the heating temperature. The furnace had a heating zone of length 0.6 m and diameter of around 0.06 m
2- A quartz tube which was sealed from one end with a piece of cork and had an inlet for primary airflow. The tube was 1.6 m long. The primary airflow was controlled using a rotameter to match the required value.
3- A quartz boat on which the sample was placed and automatically moved in the tube using a stepper driver. The length of the boat was 0.8 m.
4- A mixing and measurement cubic chamber made of polycarbonate with a side length of 0.3 m

MKS Multigas 2030 continuous FTIR gas analyzer was connected to the mixing and measurement chamber in order to analyze the gaseous effluents. Sampling was performed by connecting the sampling port to a heated sampling line (5 ft long and its temperature was 191°C) that pulled the sample gas from the chamber into the FTIR using an MKS 2380 heated pump (191°C) at atmospheric pressure.

Determination of chemical concentrations present in the sample gas was performed using the included MKS software (MG2000, Analysis Validation Utility and Gas Search Utility). Quantitative calibrations were performed by MKS and installed within the MG2000 software.

To confirm the validity of the analysis performed by MG2000, the analysis validation utility (AVU) was used on specific spectra with elevated concentrations of targeted compounds. This was to determine an estimate on the detection limits, confidence limits and maximum bias specified in ASTM D6348 (Standard Test Method for Determination of Gaseous Compounds by Extractive Direct Interface FTIR Spectroscopy) and EPA Method 320 (Vapour Phase Organic and Inorganic Emissions by Extractive FTIR). The AVU was used strictly to confirm the analysis and check spectral residues remaining. The values recorded by the AVU were not reported and used as a check. The Gas Search Utility was also used to help predict gases that may have been present and were subsequently added to the recipe.

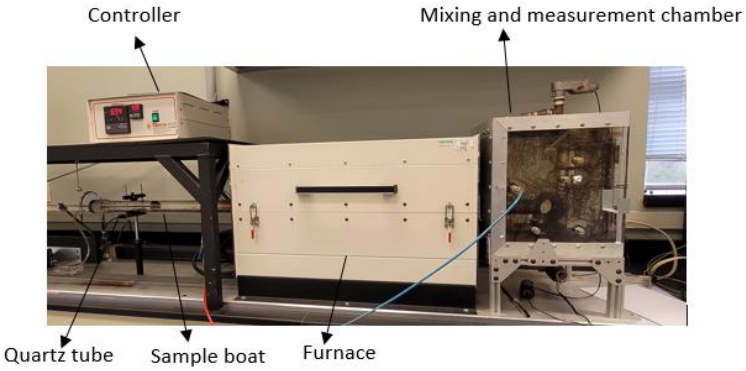

Figure 1. Photo of the tube furnace testing facility

Table 1. List of all tests conducted in the tube furnace

Material	Burning conditions	No. of runs
Black sage smudge	Oxidative pyrolysis	2
White sage smudge	Oxidative pyrolysis	2
Juniper smudge	Oxidative pyrolysis	2
tobacco	Oxidative pyrolysis	2
Black sage smudge	Well ventilated	1
Black sage smudge	Small vitiated fires	2
White sage smudge	Well ventilated	1
White sage smudge	Small vitiated fires	2
Juniper smudge	Well ventilated	1
Juniper smudge	Small vitiated fires	2
tobacco	Well ventilated	1
tobacco	Small vitiated fires	2

2.1.1 Testing procedures and conditions

All tests conducted in the tube furnace are listed in Table 1. The procedures and conditions were based on ISO 19700; Controlled equivalence ratio method for the determination of hazardous components of fire effluents- Steady-state tube furnace.

Three different burning conditions were conducted, oxidative pyrolysis, well ventilated and small vitiated fires, yet the effluent measurements by FTIR were made under two conditions; oxidative pyrolysis and small vitiated fire conditions. Oxidative pyrolysis is most representative of the natural thermal decomposition of the smudging material, which is commonly described as smouldering or non-flaming combustion. Vitiated combustion leads to smouldering combustion by limiting the amount of oxygen available to the fuel for efficient combustion, so for comparison, this thermal decomposition condition was also assessed.

During oxidative pyrolysis testing, 0.5 g of the smudging material was placed on the tube furnace boat and evenly distributed over 100 mm to achieve a sample distribution of 5 mg/mm. Figure 2 shows a photo of one of the smudging materials distributed on the boat. The airflow into the tube was 67 ml/min. The temperature of the tube furnace was adjusted at 350°C and the boat was automatically fed into the furnace at a rate of 40 mm/min. Once the boat started moving, the data acquisition from the FTIR started. The test was stopped when the concentration of carbon dioxide in the chamber reached the pretest value (~ 500 ppm). The conditions of the oxidative pyrolysis are listed in Table 2.

Figure 2. A photo of black smudge distributed on the tube furnace boat

Table 2. Conditions of oxidative pyrolysis test

Sample mass	0.5 g
Sample length	100 mm
Sample distribution	5 mg/mm
Conditioning temperature	24°C
Conditioning humidity	40% RH
Boat feed rate	40 mm/min
Primary airflow	67 mL/min
Furnace temperature	350°C

The small vitiated fire test required the calculation of the oxygen depletion from the well-ventilated test in order to get the required airflow. Thus, well ventilated testing was conducted once for each of the 4 smudging materials. However, the effluents were not measured with the FTIR. The conditions of the well-ventilated test are listed in Table 3. Basically, the same setup for the oxidative pyrolysis was used, yet a secondary air flow into the mixing chamber was required for the well-ventilated testing. The oxygen concentration inside the mixing chamber was measured using an oxygen meter.

In the well-ventilated testing, 1.5 g of the smudging material was placed on the tube furnace boat and evenly distributed over 300 mm to achieve a sample distribution of 5 mg/mm. The airflow into the tube was 333 ml/min to achieve a continuous flame, and the airflow into the mixing chamber was 1.333 L/min to oxidize the effluents. The temperature of the tube furnace was adjusted at 675°C and the boat was automatically fed into the furnace at a rate of 40 mm/min. Only the oxygen concentration in the mixing chamber was measured and the oxygen depletion for each of the smudging materials was calculated using the following formula;

Oxygen depletion = 20.95 – the average oxygen concentration measured in the chamber

Table 3. Conditions of well-ventilated test

Sample mass	1.5 g
Sample length	300 mm
Sample distribution	5 mg/mm
Conditioning temperature	24°C
Conditioning humidity	40% RH
Boat feed rate	40 mm/min
Primary airflow	333 mL/min
Secondary airflow	1.333 L/min
Furnace temperature	675°C

The oxygen depletion value was then used to calculate the airflow rates required for the small vitiated fire testing using the following formula;

Primary airflow = 1.1933*oxygen depletion

The primary airflow calculated for the tested smudging materials are listed in Table 4.

Table 4. Primary airflow required for vitiated small fire testing for the four smudging materials.

Material	Airflow (L/min)
Black sage	2.57
Juniper	2.03
White sage	2.75
Tobacco	1.9

Table 5. Conditions of small vitiated fires

Sample mass.	1.5 g
Sample length	300 mm
Sample distribution	5 mg/mm
Conditioning temperature	24°C
Conditioning humidity	40% RH
Boat feed rate	40 mm/min
Primary airflow	Oxygen depletion*1.1933 L/min
Furnace temperature	650°C

Then the small vitiated fire testing was conducted for each smudging material, following the same procedures of the of the oxidative pyrolysis with the conditions listed in

Table 5.

2.2 Room test

The concentrations of the particulate matter (PM) produced from the smudging of the 4 materials were measured in a room test facility equipped with a particle counter (Nanozen). Figure 3 and 4 show photos of the test room from outside and inside, respectively.

The room had dimensions of 2.44 m width, 3.05 m length and 2.74 m height with a total volume of approximately 20 m^3, which is approximately the same volume as a typical inmate cell. Ventilation was provided to the room through an opening of approximately 0.5 m diameter to allow fresh air exchange. One tea spoon of the smudging material (around 0.5 g) was placed on a hot plate till the PM concentration gains back the initial value before smudging which was approximately 90 minutes (on average) The temperature of the hot plate was set at 350°C. Each of the four smudging materials was tested twice for a total of eight tests.

The Nanozen provided real-time particle count, particle size distribution and mass concentration data. These data were used to calculate PM1 (mass concentration of particles with diameter less than 1 μm) PM2.5 (mass concentration of particles with diameter less than 2.5 μm), and PM10 (mass concentration of particles with diameter less than 10 μm).

Figure 3. Photo of the test room from outside

Figure 4. Photo of the test room from inside

3 Results and Discussion

3.1 Gaseous effluents

In the tube furnace tests, gaseous effluents were measured using the FTIR for the duration of 73-102 minutes for the oxidative pyrolysis (OP) tests and for 35-44 minutes for the small vitiated fire (V) tests.

Under the oxidative pyrolysis condition, the sample materials smouldered in non-flaming combustion. The peak concentrations of gaseous effluents produced during the first OP tests of the four smudging materials of Black Sage, Juniper, Tobacco and White Sage are plotted in Figure 5. The peak concentrations of CO and CO_2 were much higher than the other effluents measured, so their concentrations are shown in part-per-thousand (ppt) while other concentrations are plotted in part-per-million (ppm). Notably, Black Sage, Juniper and White Sage emitted relatively high concentrations of 1,2,3-Trimethylbenzene (TMB), acetic acid, formaldehyde, methanol and toluene. Some of the effluents emitted by tobacco (e.g., 1,2,4-TMB, acetaldehyde, dimethoxyethane (DME), ethylamine, Ethylene Glycol, Propylene glycol methyl ether (PGME) and Triethylamine) were not detected with the other smudging materials. Similar results were found in the repeated test of the OP.

In Figure 6, plotted are the peak concentrations of gaseous effluents produced during the first V tests of the four smudging materials of Black Sage, Juniper, Tobacco and White Sage. The peak concentrations of CO and CO_2 were also higher in the V tests, so they are plotted in ppt. Notably, a relatively high concentration of nitrogen dioxide was measured in the tobacco V test, along with dimethylamine, both of which were only detected in the tobacco V tests. In the V tests of other smudging materials of Black Sage, Juniper and White Sage, the less number of effluents was detected, and their concentrations were also lower than in the OP tests. In particular, some of the effluents identified with the high concentrations in the OP tests (e.g., 1,2,3 TMB, acetic acid, methanol and toluene) were not detected. Similar results were found in the repeated test of the V.

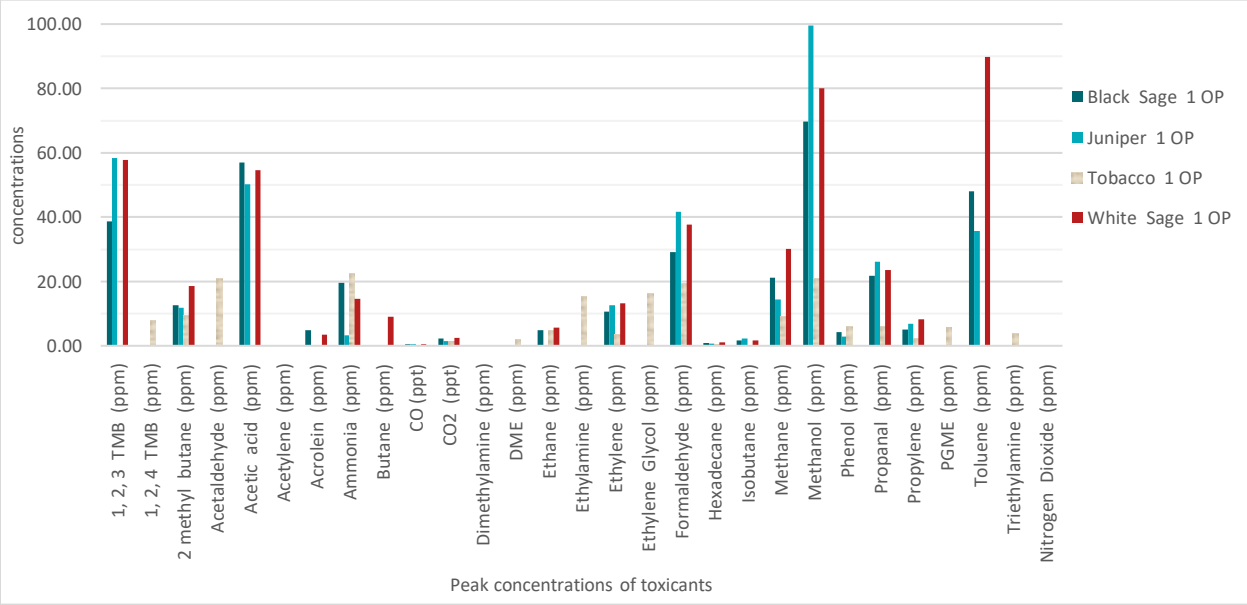

Figure 5. Peak concentrations of toxicants produced from the four samples during oxidative pyrolysis (OP) in tube furnace

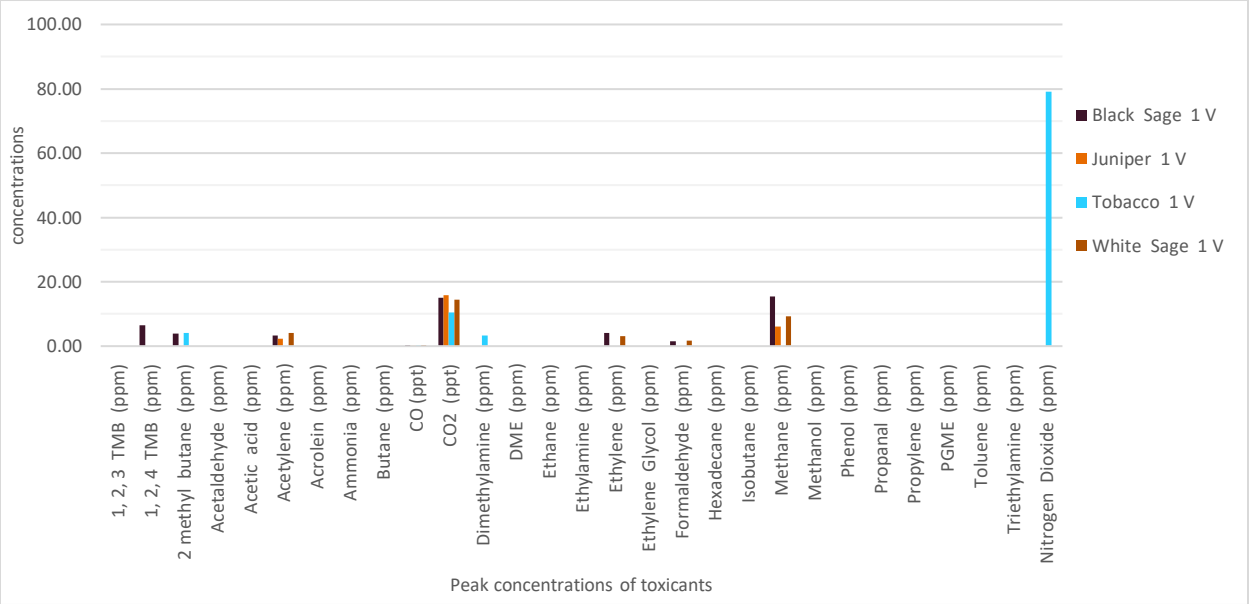

Figure 6. Peak concentrations of toxicants produced from the four samples during vitiated (V) thermal decomposition in tube furnace

Since the measurements were done in the small chamber (with the volume of 0.027 m^3) of the tube furnace, the actual concentration of the effluents in an inmate cell (with a typical volume of 19 m^3) will be lower than that measured in the chamber; whilst the same mass of the smudging material is consumed. Thus, to estimate the concentration of the effluents in a typical inmate cell, using the values obtained from the tube furnace test, the following formula was used;

$$C_{chamber} V_{chamber} = C_{inmate\ cell} V_{inmate\ cell}$$

Where $V_{chamber}$ and $V_{inmate\ cell}$ are 0.027 m^3 and 19 m^3, respectively. $C_{chamber}$ is the concentration of emission measured in the tube test while $C_{inmate\ cell}$ is the value expected in an inmate cell.

The estimated concentrations in an inmate cell (C_{inmate}) are plotted in Figure 7 for oxidative pyrolysis conditions and Figure 8 for small vitiated fire condition. In comparison to the peak concentration measured in the tube tests, the estimated concentrations are significantly low due to the dilution in the large volume of the inmate cell.

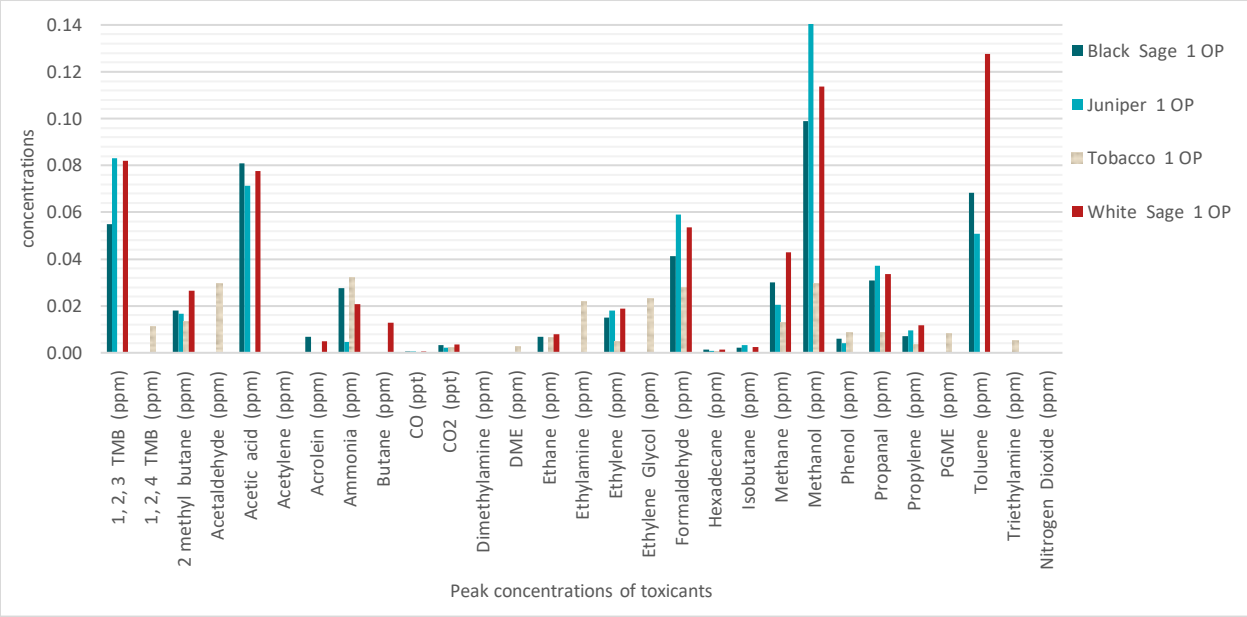

Figure 7. Estimated peak concentrations of toxicants produced from the four samples during oxidative pyrolysis (OP) in typical inmate cell

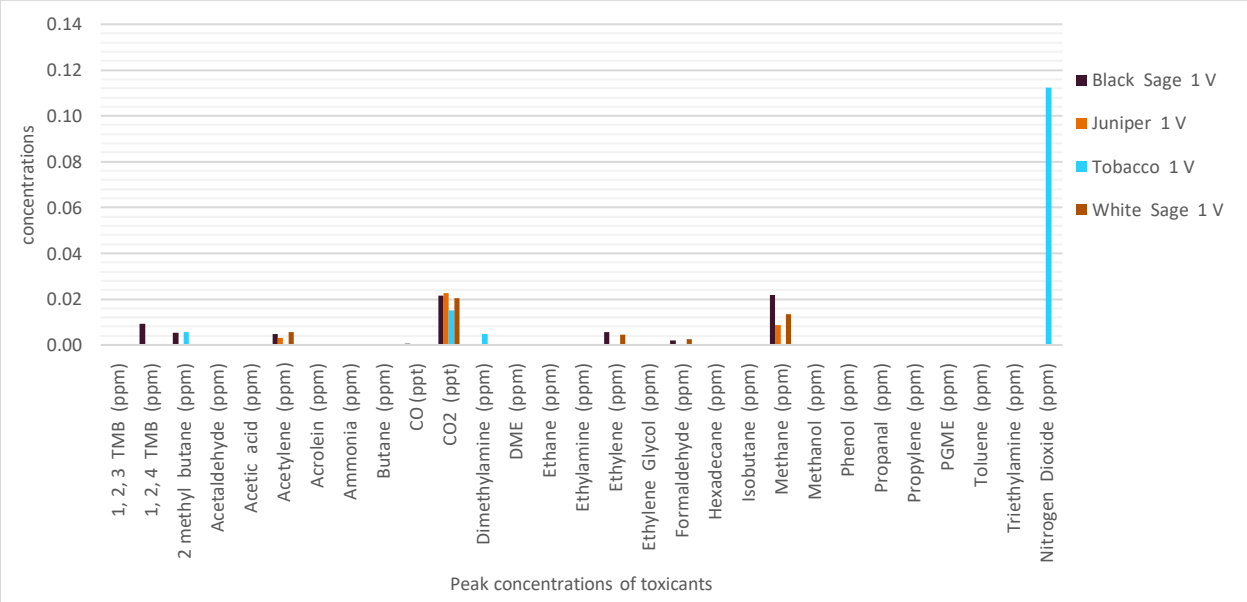

Figure 8. Estimated peak concentrations of toxicants produced from the four samples during vitiated (V) thermal decomposition in typical inmate cell

In order to assess the potential hazard from smudging in inmate cell, it was required to compare the estimated effluent concentrations against standard exposure limits. Since there was no single source that contains exposure limit data for all the detected chemicals, data was compiled from a variety of sources. Data sources included the U.S. Environmental Protection Agency (EPA), the Canada Labour Code (CLC), the American Conference of Governmental Industrial Hygienists (ACGIH), and the Occupational Safety and Health Administration (OSHA). Moreover, the estimated effluent concentrations were also compared against the Acute

Exposure Guideline Limits level 1 (AEGL-1 by EPA), which is defined as the concentration of a substance above which the general population could experience notably, non-disabling and transient discomfort or certain asymptomatic non-sensory effects. A compiled list of exposure limits published by the EPA, CLC, ACGIH, and OSHA are provided in Appendix D of the supplement toxicity analysis report.

The comparison of the estimated concentrations with the standard exposure limits (e.g., AEGL-1, CLC, ACGIH, OSHA) showed that the concentrations of smudging effluents present in a typical inmate cell are at least one order of magnitude less than acceptable exposure limits. The only exception is acrolein, which is estimated to peak at 0.01 ppm in the inmate cell; however, this value is still below the short-term exposure limit and ceiling limit (i.e., the “not-to exceed” concentrations regardless of the duration of exposure) of 0.03 ppm. In addition, this peak acrolein concentration only lasts for a few minutes during the combustion event, after which it falls even further below the short term and ceiling limits. This finding agrees with the on-site measurements conducted in CSC centers in Dorchester- New Brunswick [5] and Saskatoon [6]. Both studies measured the gaseous effluents produced in a smudging room during a smudging activity and concluded that all parameters tested were below the Threshold Limit Values - Time Weighted Average (TLV-TWA) and TLV-ceilings.

There were no published exposure limits for some chemicals (e.g., 2-methyl butane, acetylene, DME, Ethane, Ethylene, Ethylene Glycol, Hexadecane, Isobutane, Methane, Propylene, Propylene glycol methyl ether (PGME)) found in the combustion effluent, however, given that no exposure limits were exceeded even for chemicals with exposure limits in the 1/100th range, it can be conservatively assumed that exposure limits for chemicals with no established values (and of similar chemical composition) would not be exceeded.

3.2 Particulate Matter

Smoke particles/Particulate matters are released in varying sizes during the combustion of organic materials, and inhalation of particulate matters (as shown in Figure 9) can cause health effect, which is dependent on the concentration and size of the particulate matters. Thus, the peak and average concentrations (in $\mu g/m^3$) of PM1, PM2.5 and PM10 were collected from the eight tests conducted in the room. Figure 10 shows the values measured from the eight room tests. It should be noted that the average and peak PM values for tests 1 and 2 for each smudging material are different due to the uncontrolled burning of the material –i.e the air flow inside the room was not controlled- and random nature of fire. Since a typical inmate cell has a volume of 19 m^3, the PM values obtained from the test room of the volume of 20 m^3 were representative of the values expected during a real smudging activity in an inmate cell with ventilation. However, if the inmate cell is not well ventilated, the concentration of PM should be higher.

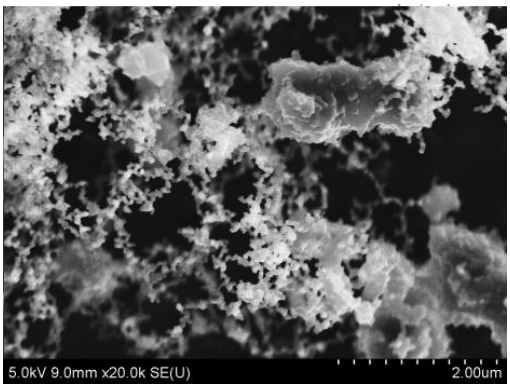

Figure 9. Smoke particulate matter image of white sage samples (image taken using a Scanning Electron Microscopy)

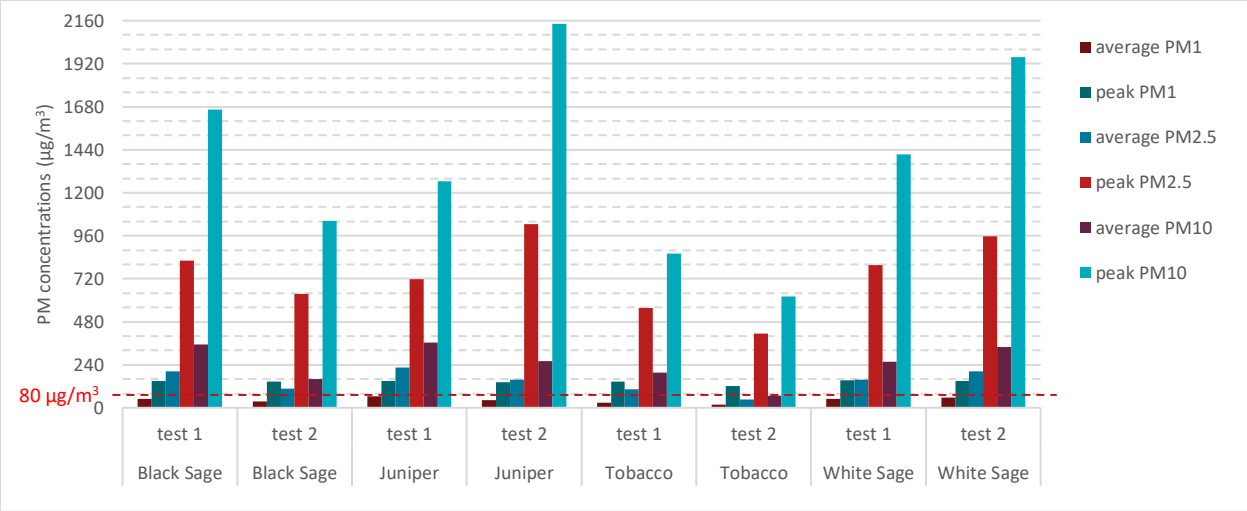

Figure 10. Peak and average concentration of particulate matter measured in the room tests

The assessment of the hazard exposure to PM produced during smudging activities was also crucial, since epidemiological studies showed a relationship between increased concentrations of PM1, PM2.5 and PM10 and daily deaths, hospital admissions, and cardiac and respiratory illnesses [7], [8]. The depth of travel of the PM into the respiratory system depends on its size (diameter). PM10 can penetrate and deposit within the upper respiratory tract [7], [8]. PM2.5 can travel further and deposit within the alveoli [7], [8]. PM1 can reach the systemic circulation [7], [8].

Currently the only Canada-wide standard for indoor air quality states to keep the levels of PM2.5 as low as possible [9] and doesn't provide specific guidelines. Moreover, Health Canada states that PM10 and PM2.5 are considered to be non-threshold substances, meaning that health effects may occur at any level of exposure. The Canada-Wide Standard for outdoor air quality guidelines for PM2.5 is 28 µg/m^3 averaged over a 24-hour period [10], [11]. Moreover, the only outdoor air quality guideline is stated by the province of Alberta where the maximum limit is 80 µg/m^3 for PM2.5 for a 1 hour period [11].

Therefore, the least limit that can be considered for PM is to keep the concentration of indoor PM2.5 lower than the outdoor limit stated by the Province of Alberta for 1-hour period. It should be noted that a 1-hour exposure limit is more relevant to the duration of smudging activity.

Figure 11 - Figure 14 show the PM concentrations measured during the first 20 minutes from the smudging of the 4 materials. The data from the room testing show that PM2.5 concentrations exceeded 80 µg/m^3 for the first 20-minute of smudging, and the averaged values over the test duration were also higher than the limit (see Figure 10). Nevertheless, the concentration of PM was higher than 80 µg/m^3 during the first 5 minutes. Even if it was assumed that the PM2.5 concentration was zero after 20 minutes up to one hour, the average PM2.5 concentration inside a typical inmate cell that is well ventilated would exceed the Alberta outdoor air quality limit of 80 µg/m^3. This is also expected in case of using combinations of some or all smudging materials, since the average PM2.5 from all of them already exceeded 100 µg/m^3. Moreover, PM can travel to adjacent spaces/cells in case exhaustion is not provided in the cell in which smudging is conducted. The possibility of the spread of the smudging effluents to other locations increases when air is recirculated within a facility. For example, in wet cells (cells with toilets) with exhaust systems (designed according to ASHRAE 62.2), the exhaust rate is likely be insufficient to keep the PM concentrations below the limit of 80 µg/m^3 (although these

cells are not re-circulated). In case of dry cells (with no toilets), the vent systems are re-circulated, which enables the spread of the smudging effluents.

The on-site study in CSC center in Saskatoon [6] reported the PM concentrations of 40-80 µg/m^3. However, this value wasn't compared against any limit. This value is much less than that measured in our test, since the smudging activity in the Saskatoon study was conducted in a smudging room that had two ceiling diffusers and an exhaust vent while ventilation was provided to our testing room through an opening of approximately 0.5 m diameter.

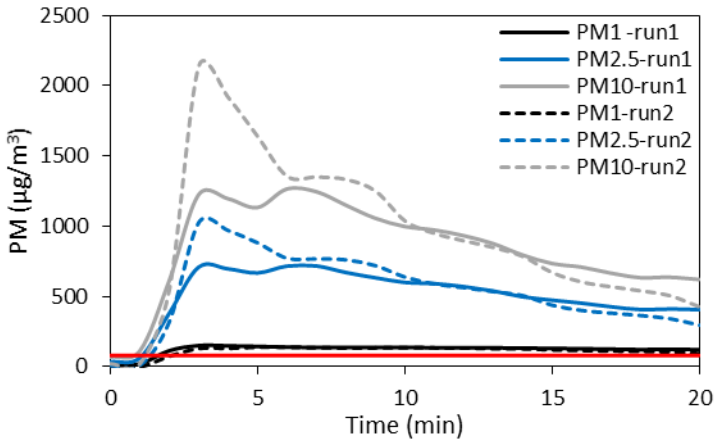

Figure 11. PM profiles during the first 20 mins of Juniper smudging in the room test. The red line represents the maximum limit for PM2.5 (80 µg/m^3)

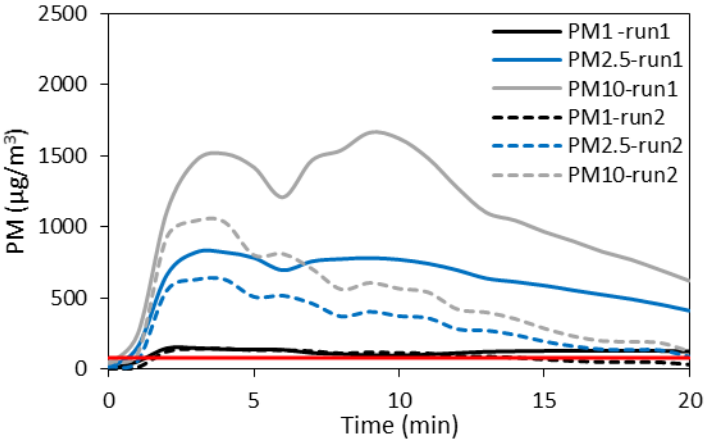

Figure 12. PM profiles during the first 20 mins of black sage smudging in the room test. The red line represents the maximum limit for PM2.5 (80 µg/m^3)

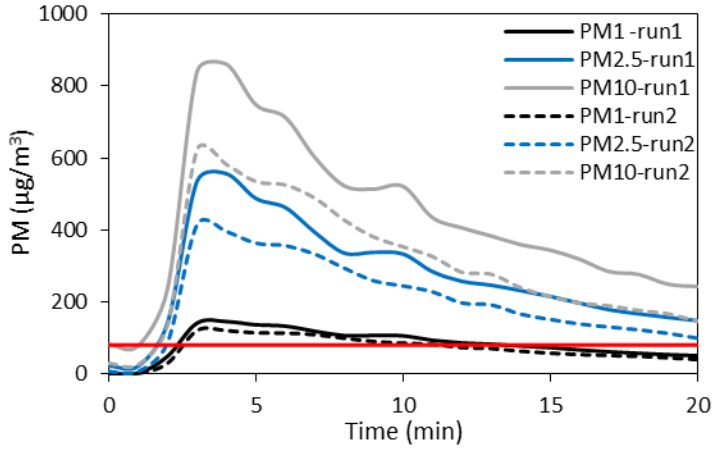

Figure 13. PM profiles during the first 20 mins of tobacco smudging in the room test. The red line represents the maximum limit for PM2.5 (80 µg/m^3)

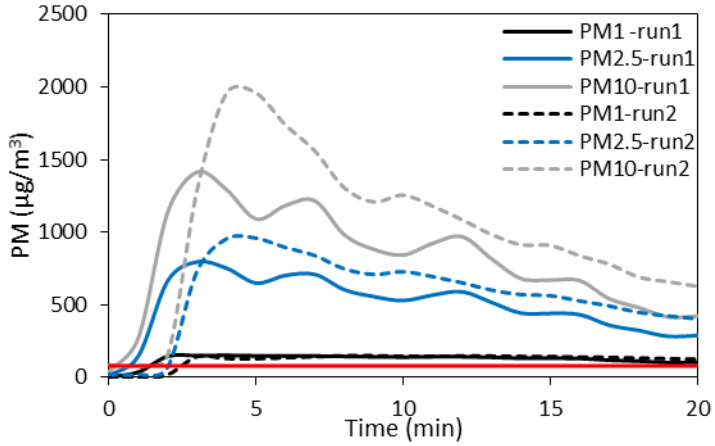

Figure 14. PM profiles during the first 20 mins of white sage smudging in the room test. The red line represents the maximum limit for PM2.5 (80 µg/m^3)

Thus, it can be concluded that PM produced during smudging presents risk to inmates and correctional facility officers and mitigation strategies should be implemented to reduce this risk.

4 Mitigation Strategies

Ideally, it is required to perform all the smudging activities outdoors or in an outdoor enclosure, e.g., temporary tent, etc. Otherwise, if smudging activities must be conducted indoors, the following controls should be implemented in order to mitigate risk:

- Advanced notification and approval of the day, time, and place of the planned smudging activity,
- Posted signage outside the room where the smudging activity will take place,
- Smudging activities should be limited to designated locations with compatible fire protection systems and adequate ventilation,
- If smudging is conducted outside of a designated location, a fixed or portable air filtration system should be provided.

According to CSC's Technical Criteria (TC) for Correctional Institutions [12], designated group rooms are required to have supplemental exhaust more than the normal air exchange rate between two and four air changes per hour (ACH); however, dedicated air exhaust systems are not required in "(a) inmate cells or bedrooms, including in segregation, (b) private family visit spaces, and (c) any other space not noted above" where smudging is approved per CD 259 [12], [13]

Therefore, the best practice to minimize risk and control exposure would be to limit smudging activities only to designated locations equipped with the special ventilation requirements defined in Section 10 of the TC [12]. In case the smudging activities to be allowed to continue outside of designated locations, and supplemental exhaust is not provided, then an air filtration system should be used. Manufacturers, such as AllerAir, market air filtration systems designed for smudging activities and can be consulted to identify the best product to use in non-designated smudging locations [14].

5 Conclusions and Recommendations

In this task, four smudging materials (black sage, white sage, juniper and tobacco) were tested in a tube furnace and a testing room facilities to determine gaseous effluents and particulate matter (PM), respectively. Then based on the measured values, the concentrations of effluents in an inmate cell were calculated to assess the hazard exposure to inmates and correctional facility staff.

The gaseous effluents were compared to exposure limits from different sources including Acute Exposure Guide Limits. It was concluded that, the concentrations of gaseous effluents from the smudging of the four common materials inside an inmate cell would be less than allowable exposure limits.

For complete hazard assessment, particulate matters were also measured. The measured PM2.5 in a test room having a similar volume of a typical inmate cell was high, exceeding the PM exposure limit of 80 $\mu g/m^3$ defined by the province of Alberta for an outdoor, one-hour, average PM2.5 exposure.The current guidelines for indoor air quality in Canada state to “keep indoor levels of PM2.5 as low as possible.” Moreover, there is no Canada-Wide Standard outdoor air quality guideline for short term exposures (e.g., 1-hour or less as with smudging).

The following mitigation strategies were recommended to reduce the risk of adverse health effects from exposure to PM: 1) Require advanced notification and approval of smudging activities, 2) Post warning signage, 3) Limit smudging to designated locations with compatible fire protection systems and appropriate fire safety equipment, 4) Limit smudging to designated locations with special ventilation as defined in Section 10 of the TC, and 5) utilize an air filtration system when smudging is conducted outside of a designated location.

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Supplement. Toxicity analysis report