

Research Division

Summary Document:

Operator Exposure to Emissions from Lawn and Garden Equipment

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Abstract: Exposures to air pollutants from gasoline-powered lawn and garden equipment could be a health concern for operators who use these devices on a daily basis. The California Air Resources Board (CARB) staff conducted a study and preliminary findings indicate elevated exposures to criteria and toxic air pollutants for operators of gasoline-powered devices compared to electric devices and background levels. Of the devices tested, gasoline-powered chainsaws emitted the highest amounts of VOCs. The increased exposures to benzene and 1,3-butadiene from gasoline-powered chainsaws were estimated to produce between 41 to 158, with an average of 81, possible additional cancers per million workers exposed. Moving towards zero-emission technologies may help reduce operators' exposure and their associated health risks.

1. BACKGROUND

Gasoline-powered lawn and garden equipment are known to emit a number of criteria and toxic air pollutants. Operators of these devices are usually subjected to high exposures to these air pollutants due to their close proximity to the exhaust outlets during operations. A previous study found that carbon monoxide (CO), PM_{2.5}, and formaldehyde exposure levels from gasoline-powered lawn and garden equipment were several times higher than relevant health based standards¹. Therefore, there may be a health concern for professional gardeners and landscapers who use these devices on a daily basis. However, this is difficult to determine since up-to-date information is limited for the exposures and health risks associated with the use of gasoline-powered lawn and garden equipment in California.

2. TESTING AND ANALYTICAL METHODS

CARB staff conducted a study to estimate operators' exposure to air pollutants and noise from lawn and garden equipment and analyzed associated health risks. This study was conducted in two steps.

First, a total of 23 new lawn and garden devices were tested for their contributions to an operator's exposure to air pollutants and noise. These devices included 18 gasoline-powered and five electric devices, and covered six categories: chainsaws, hedge trimmers, leaf blowers, string trimmers, push lawn mowers, and riding lawn mowers.

Operators used each device to perform typical gardening activities for three tests, each lasting 10 - 15 minutes. During the tests, operators wore a small backpack with air pollutant monitors to measure real-time exposures to ultrafine particles (UFP), PM_{2.5}, PM₁₀, black carbon (BC), CO, and noise at their breathing zone. Another set of identical monitors measured concurrent background concentrations.

¹ Baldauf *et al.*, (2006) Air contaminant exposures during the operation of lawn and garden equipment, *Journal of Exposure Science and Environmental Epidemiology*, 16, 362–370

Second, in a separate part of the study, the operator's exposure to volatile organic compounds (VOCs) emissions were measured for a new electric chainsaw, a used gasoline-powered chainsaw, and six other new gasoline-powered devices. For each device tested in this part of the study, the operators wore a backpack with a 6-L canister to collect a 45-minute air sample at their breathing zone while they were performing typical gardening activities. Concurrently, another canister was used to collect the air at a background site. VOC speciation and concentrations were determined at CARB's chemical analysis laboratory.

Cancer and non-cancer risks were estimated for five substances (benzene, toluene, ethylbenzene, and xylene or BTEX, and 1,3-butadiene) using CARB's HARP2 Risk Assessment Standalone Tool. For cancer risk assessment, a 25-year exposure duration was selected, and the exposure frequencies were determined from the annual hours of use defaults from the CARB OFFROAD2007 model². For non-cancer risk assessment, time weighted exposure levels were compared to the Office of Environmental Health Hazard Assessment's (OEHHA) acute (one hour), and chronic (at least 12% of a lifetime, about 8 years) Reference Exposure Levels (REL), the concentrations below which no adverse health effects are anticipated.

3. RESULTS

All gasoline-powered devices increased the operator's exposure to VOCs, including benzene and 1,3-butadiene which are carcinogens with no safe levels of exposure. Table 1 shows the incremental exposure concentrations to benzene and 1,3-butadiene and their associated cancer risks. The highest VOC exposures were from the chainsaws, with an average of 170 $\mu\text{g}/\text{m}^3$ for benzene and 22 $\mu\text{g}/\text{m}^3$ for 1,3-butadiene. Exposures to these two carcinogens from gasoline-powered chainsaws were estimated to produce between 41 to 158 possible additional cancers per million workers exposed depending on model type, with an average of 81 possible additional cancers per million workers exposed. Cancer risks from the remaining devices ranged from 2 to 6 possible additional cancers per million workers exposed. Operators of gasoline-powered devices could potentially double their current cancer risks from benzene and 1,3-butadiene which are estimated to be 115 possible additional cancers per million exposed due to baseline exposures from predominantly mobile sources³. For non-cancer risks, exposures from gasoline-powered chainsaws were up to 14 times above the acute RELs, and up to 6 times above the chronic RELs. In contrast, use of the electric devices did not increase the operator's VOC exposure.

² https://www.arb.ca.gov/msei/offroad2007_docs.htm

³ <https://arb.ca.gov/adam/toxics/statesubstance.html>

Table 1 Incremental exposure concentrations to benzene and 1,3-butadiene and associated cancer risks

Power	Type	Device	Exposure concentration ($\mu\text{g}/\text{m}^3$)		Cancer risk (cancers/million exposed)		
			Benzene	1,3-Butadiene	Benzene	1,3-Butadiene	Total
Electric	Chainsaw	#1	0	0	0	0	0
Gasoline	Chainsaw	#2	381	34	103	55	158
		#3 *	160	26	43	42	85
		#4	116	23	31	37	69
		#5	94	18	25	29	54
		#2 **	96	9	26	15	41
		Mean	170	22	46	36	81
Gasoline	Leaf blower	#6	15	2	3	3	6
Gasoline	String trimmer	#7	15	2	2	2	3
Gasoline	Push mower	#8	5	0	1	1	2

* This is a used device; all others are new devices.

** This test was done with the ratio of the duration of cutting vs. idling equal to 1:3; all other chainsaws were tested at a ratio of 1:1.

For other air pollutants measured and noise, high short-term exposures were also observed for the gasoline-powered devices; some of these short-term exposures exceeded the levels of the relevant National and California Ambient Air Quality Standards. Compared to the electric devices, average exposures from the gasoline-powered devices were about 1.2 to 70 times higher. Such differences were statistically significant for UFP, BC, CO, and noise. For $\text{PM}_{2.5}$ and PM_{10} , the differences between gasoline-powered and electric devices were much smaller, possibly due to large particle resuspension from mechanical movement. Based on the results from the current study, CARB staff intends to undertake additional tests of operator's exposure to VOCs in the future.

4. CONCLUSION

Moving towards zero-emission technologies may reduce operators' exposure to harmful air pollutants and noise from lawn and garden equipment and their associated health risks.