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BACKGROUND

Black carbon (BC) particles can produce negative health and climatological effects. Average 24 hr. exposures of 1.34 $\mu\text{g}/\text{m}^3$ in utero/during the first-year of life may increase the risk of developing childhood asthma, and low levels (mean 0.8 $\mu\text{g}/\text{m}^3$) are associated with increased bronchitis and asthma symptoms in school children. Mean exposures $\leq 1.2 \mu\text{g}/\text{m}^3$ are associated with increased respiratory and coronary heart disease mortality.

While occupational and exposure studies have assessed BC in various settings, farmer exposure has not been addressed, despite farmers' frequent work with heavy diesel machinery.

Farmer exposure measurements were therefore necessary. A microAethalometer[®] (Aethlabs) real-time BC monitor was worn by farmers near the breathing zone during harvest to evaluate exposure.

OBJECTIVES

Study objectives were to:

- 1) Identify task-specific black carbon (BC) exposures due to diesel exhaust (a known carcinogen) from heavy machinery (i.e. tractor/combines) on farms during harvest
- 2) Characterize time-weighted concentrations (TWCs) in typical tasks
- 3) Quantify daily farmer exposures, characterizing average exposure levels and peaks

MATERIALS AND METHODS

Methods

- 16 farmers participated over 20 visits

Measurements

- A microAeth[®] (MA) collected real-time farmer exposure data, while a third-party observer recorded daily tasks, typically 7 hrs
- A micro-cyclone (Aethlabs) with a 2.5 $\mu\text{g}/\text{m}^3$ cut-point inhibited interference of road and other dust
- 30-sec. average samples were taken at 50 ml/min

Sites and Activities

- Wide-range in farm size and types of operation
- Activities included harvest-related tasks
- Frequently repeated tasks were separated into 13 categories
- TWC_{tasks} were calculated as follows: $TWC_{\text{task}} = \frac{Ct}{\Sigma T_{\text{task}}}$, where average task conc./day (C) were multiplied by Time_{total} to complete task (t) divided by sum daily task-time

Tasks Identified

- | | |
|-----------------------------------|----------------------------|
| A) Drive 4-wheeler | B) Skid-loader unspecified |
| C) Empty transport | D) Full transport |
| E) Animal work | F) Load/Unload |
| G) Drive | H) Harvest: Combine |
| I) Miscellaneous combine | J) Use tractor |
| K) Tractor/combine indoor-outdoor | L) Grain bin work |
| M) Work in shop | |

Analysis

- One-way ANOVA (miniTab v. 17) tested for statistically significant differences in mean exposures between 13 task groups, and for differences in mean TWC_{tasks} exposures
- Post-hoc analyses for statistical similarity between tasks and TWC_{tasks}

RESULTS, TASKS

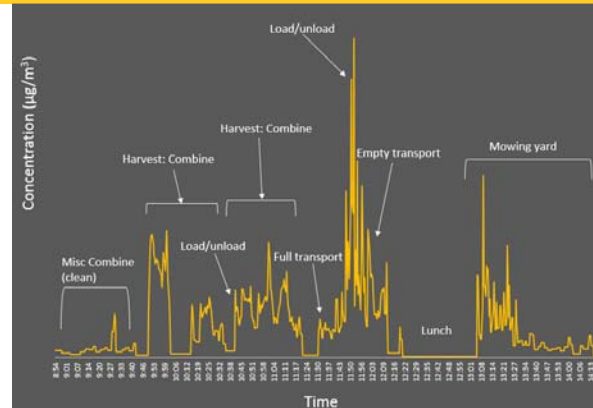


Fig. 1 Daily task sequence of BC concentrations

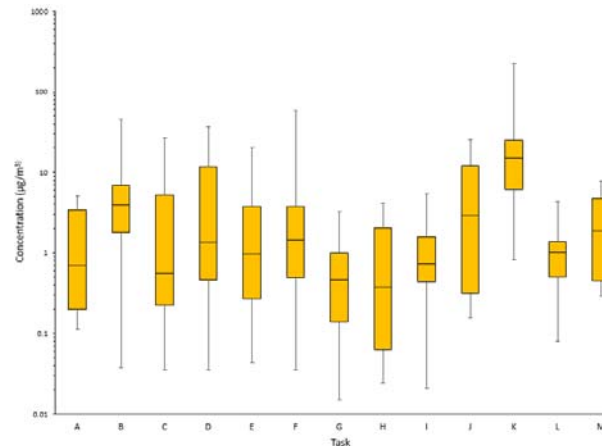


Fig. 2 Average task exposure boxplot, error bars contain min/max exposures

Table 1 Summary statistics for task concentrations, sorted by GMs

Tasks	N	GM (GSD)	Group
K) Tractor/combine I-O	22	13.15 (3.31)	a
B) Skid-loader unspecified	17	3.67 (4.83)	ab
J) Use tractor	14	2.10 (6.72)	ab
M) Work in shop	8	1.47 (3.95)	abc
D) Full transport	17	1.46 (7.35)	bc
F) Load/Unload	30	1.44 (5.39)	b
E) Animal work	24	0.98 (6.10)	bc
C) Empty transport	17	0.95 (9.27)	bc
I) Misc. Combine	18	0.67 (4.92)	bc
L) Grain bin work	7	0.67 (4.39)	bc
A) Drive 4-wheeler	9	0.77 (4.23)	bc
H) Harvest: Combine	9	0.38 (7.81)	bc
G) Drive	39	0.34 (4.22)	c

Values reported in $\mu\text{g}/\text{m}^3$. GMs with different letters are significantly different ($\alpha = 0.05$)

RESULTS, TWC_{tasks} AND PEAKS

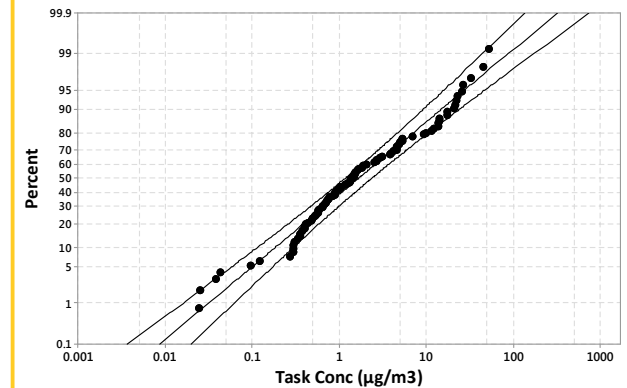


Fig. 3 Log-normal probability plot of average TWC_{tasks}

Table 2 Number of visits (of 20) peak exposure $\geq 20, 50, 100, 200$ or $300 \mu\text{g}/\text{m}^3$

Peak ($\mu\text{g}/\text{m}^3$)	# of visits	% of visits
≥ 20	17	85
≥ 50	11	55
≥ 100	8	40
≥ 200	3	15
≥ 300	2	10

CONCLUSIONS

- Farmers experienced BC exposure on a daily basis – average daily BC exposures ranged from 0-11 $\mu\text{g}/\text{m}^3$ – levels equal to, or higher than BC levels associated with health effects in the literature
- Specific tasks led to 3 groups of statistically different exposures (Table 1), while TWC_{tasks} did not, likely due to smaller TWC_{tasks} sample size
- Task K, whereby farmers were exposed to exhaust from tractors, combines, or loader-tractors' (recently or currently running) in/outdoor consistently resulted in highest BC concentrations
- Overall BC exposures in farmers were caused by a combination of regular acute peaks and unexpectedly high intermittent BC levels, not necessarily by specific tasks
- Annual ambient mean (2010) estimated US BC concentration of 0.3 $\mu\text{g}/\text{m}^3$ is far lower than exposure many farmers experience daily, farmer exposure exceeds full-time worker and homemaker exposures in existing literature

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