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Wildfire Ash: Impacts on Forage Crops

The Problem

The impacts of wildfire ash deposition on crops grazed or harvested for livestock feed were largely unknown, especially relative to burned structures containing unknown levels of contaminants from household products, vehicles, businesses and residential chemicals. Notable fires during the sampling period were the Carr, Mendocino Complex, and Camp Fires in Northern California.

Smoke fills the air in the Sacramento Valley during the Camp Fire- 2018.

The Study

During the fire season of 2018, we sampled:

- ✓ 26 irrigated pastures
- ✓ 20 hay stacks
- ✓ 15 corn silage piles

from locations throughout California, either affected or not affected by wildfire ash. All samples were analyzed for:

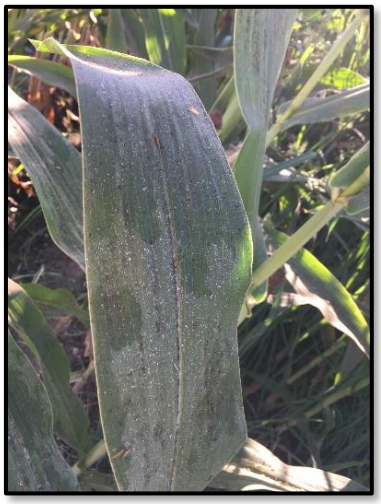
Heavy Metals:

Copper
Iron
Manganese
Molybdenum
Zinc
Cadmium
Lead
Mercury
Arsenic

Minerals:

Calcium
Magnesium
Phosphorus
Potassium
Sulfur

A subset of 37 samples were analyzed for chemical compounds by gas and liquid chromatography–mass spectrometry organic chemical screens. These screens detect a large number of organic compounds belonging to diverse chemical classes, including pesticides, environmental contaminants, drugs, and other natural products.

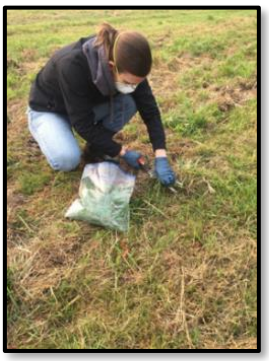


A corn plant in Northern California, with ash from a wildfire deposited on the leaves.

The Results

Compounds of interest that were detected in 6 of 37 forage samples included:

- Ethoprop (pasture, hay)
- Caffeine (pasture)
- Linalool (hay)
- 1H-pyrrole-2'5-dione (hay)
- Acetamiprid (silage)



Karle collecting a pasture sample in Butte County during the Camp Fire-2018.

Detection of these compounds was not associated with forage type or geographic location. It is possible that some chemicals could have been detected due to naturally occurring plant compounds or legacy chemicals.

Lead, mercury, arsenic and cadmium were not detected in any samples. Copper, manganese, zinc, iron, and molybdenum were detected in some samples, with most levels below the maximum tolerable limit (MTL) for cattle as published in *Mineral Tolerance of Animals* (NRC 2005; Table 1).

Table 1: Metal Concentrations

Metal	Range (ppm)	Median (ppm)	Mean (ppm)	Dietary Maximum Tolerable Level for Cattle (ppm)[1]
Copper	1.4 - 86	4.25	8.5	40[2]
Manganese	3.8 - 500	23.0	40.8	2,000
Zinc	4.8 – 65	9.6	14.2	500
Iron	14 – 1,900	81.0	158.3	500
Molybdenum	0 – 2.8	0	0.25	5

[1] Maximum tolerable levels are for cattle on a dry matter basis. Consult the appropriate section of NRC (2005) for additional considerations.

[2] Dietary maximum tolerable level for sheep is 15 mg Cu/kg dry matter.

"Lead, mercury, arsenic and cadmium were not detected in any samples."

To determine the effects of heavy metal levels, we conducted an analysis of variance using factors of forage source (pasture, hay, silage), presence of ash (Yes or No), and their interaction. There was a tendency for copper to vary by forage type ($P = 0.07$) and it was higher in fields not affected by ash ($P = 0.03$). Zinc was affected by forage source ($P < 0.01$), but not by the presence of ash ($P = 0.32$). Manganese was significantly impacted by forage source ($P = 0.04$), but not by ash ($P = 0.12$). Iron was impacted by forage source ($P = 0.02$), but not by the presence of ash ($P = 0.19$). See Table 2, next page.

Table 2: Metal Concentrations by Forage Source and Presence of Wildfire Ash

Forage Source				
	Copper (ppm)	**Zinc (ppm)**	**Manganese (ppm)**	**Iron (ppm)**
Pasture	4.4 a[1]	12.3 a	62.8 b	94 a
Silage	15.1 b	10.1 a	12.9 a	80.9 a
Hay	7.7 ab	21.9 b	54.0 b	291 b
Presence of Ash (Yes/No)				
Yes	4.9 a	13.6 a	30.6 a	199.0 a
No	13.2 b	15.9 a	55.9 a	111.5 a

[1]Within a column, concentrations with the same letter are not different at $P = 0.05$

Minerals were detected at generally low levels across all forage types, with only potassium detected at higher levels in several samples (Table 3).

Table 3: Mineral Concentrations

Mineral	Range (%)	Median (%)	Mean (%)	Dietary Maximum Tolerable Level for Cattle (%)[1]
Calcium	0.15 – 1.4	0.37	0.49	1.5
Phosphorus	0.1 – 0.45	0.22	0.22	0.7
Magnesium	0.09 – 0.43	0.25	0.25	0.6
Potassium	0.26 – 3.58	1.71	1.68	2.0
Sulfur	0.09 – 0.44	0.19	0.20	0.4

[1] Maximum tolerable levels are for cattle on a dry matter basis. Consult the appropriate section of NRC (2005) for additional considerations.

The Take Home

Though there were some compounds of interest and a few high levels of heavy metals detected in our samples, results were generally unremarkable and did not suggest that wildfire ash was consistently associated with heavy metals in forages. The positive samples were randomly distributed and not all from areas affected by wildfire ash. While more detailed and controlled studies could provide additional information, these results indicate that forages affected by wildfire ash deposition are likely safe for livestock to consume.

If you have forages that may be affected by ash deposition, evaluate the concentrations of minerals before formulating a ration. If you're exceptionally concerned about toxicity from contamination and cannot dilute with unaffected feed, isolate and test feed for heavy metals and organic compounds. Reach out to your local UCCE Farm Advisor if you have questions regarding taking a representative sample, choosing a lab, lab analyses, or interpreting your results.

The Team

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Funding

University of California- Division of Agriculture and Natural Resources
California Department of Food and Agriculture

References

National Research Council. 2005. Mineral Tolerance of Animals . Vol. 2nd rev. ed., National Academy Press, Washington, DC.