



Relation between malodor, ambient hydrogen sulfide, and health in a community bordering a landfill

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Orange County Solid Waste Advisory Board Meeting

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Rogers-Eubanks Road Timeline up to 1972



1780s founding of the Rogers-Eubanks community

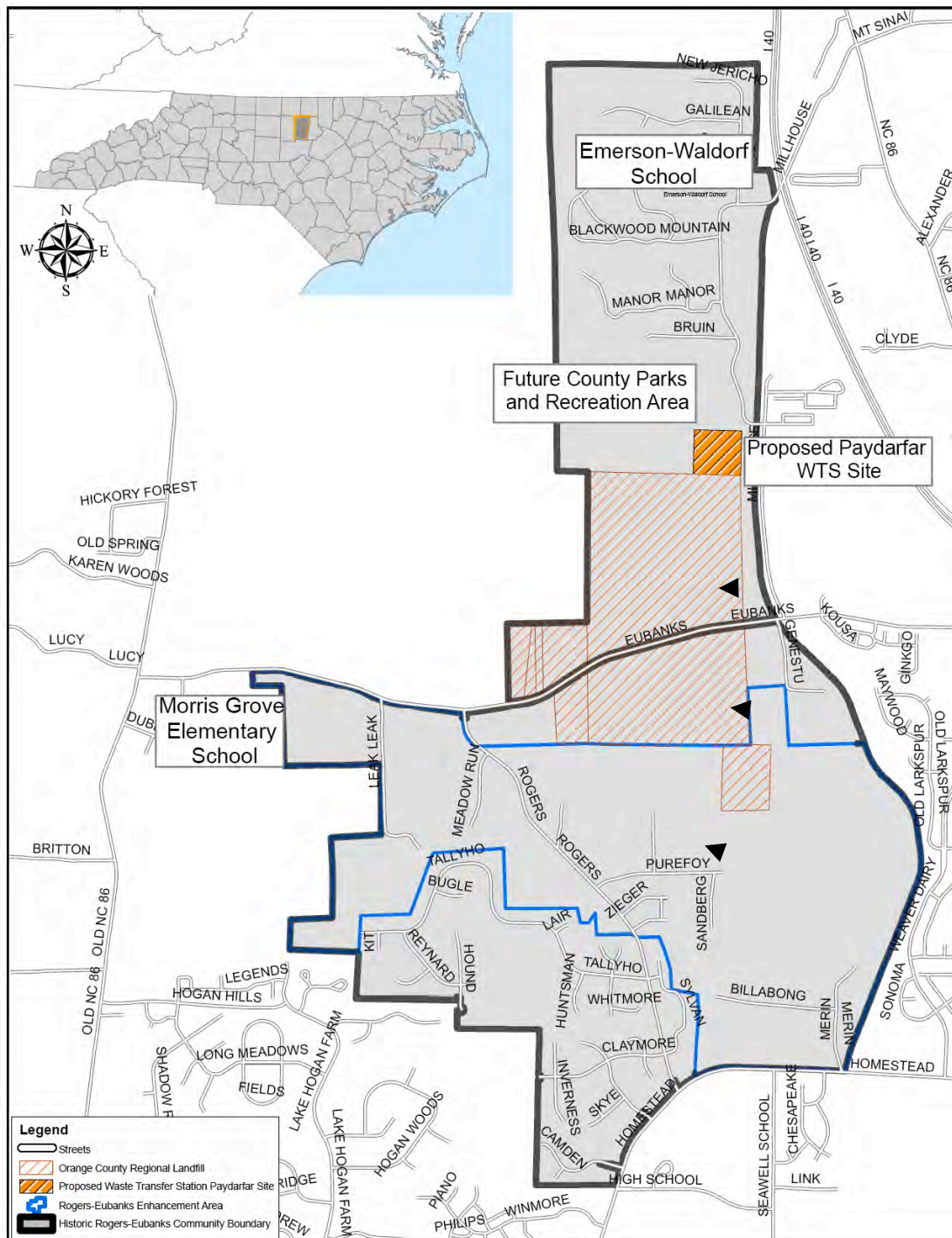
1870s-1920s successful farming and leadership by freed slaves

1930s-1970s economic decline / land use changes

1972 County regional landfill sited in Rogers-Eubanks community:

- B.B. Olive, the Rogers-Eubanks community, and Orange County Planning Board oppose landfill site based on water contamination concerns
- Orange County Commissioners reject Planning Board's recommendation and move forward with Eubanks Road site
- NC Superior Court rules in favor of Orange Co. (New Hope Improvement Association v. Orange Co.)
- Local governments promise landfill will close by 1982 and residents will be connected to basic amenities (e.g., water, sewer, paved roads, recreation center, community park)





**Proximity of landfills to:
Rogers-Eubanks Road community
4 miles north of UNC campus**

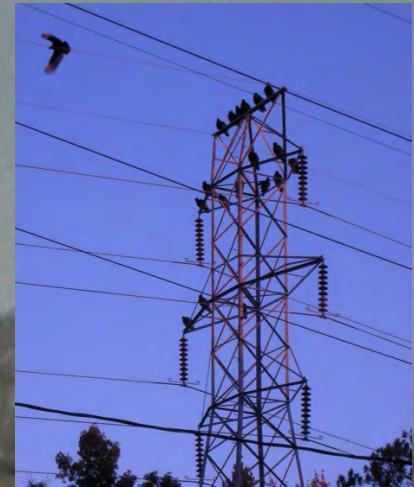
Unlined C&D landfill
north of Eubanks Rd

Subtitle D MSWL
bordering community

**Rogers-Eubanks Rd
community**

Current EJ concerns in Rogers-Eubanks community

- **Odor and air quality (hydrogen sulfide)**
- Safe water and sewer infrastructure
- Buzzards and vermin
- Illegal dumping
- Safe closure of landfill
- Noise
- Traffic



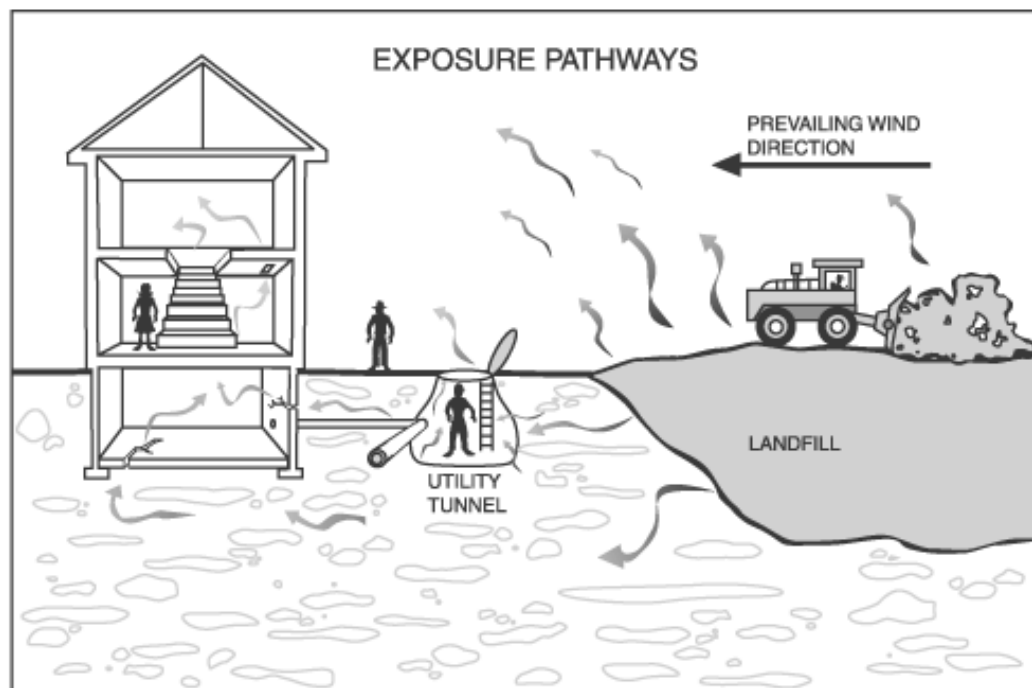
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Organizing to take control and empower



Landfill malodor and health



- Previous studies lack concurrent measurement of air pollutants and health outcomes
- Hydrogen sulfide (H_2S): distinct rotten egg smell, associated with anaerobic decomposition process in landfills
- Anaerobic decomposition produces a complex mixture of gases

- Relative to methane and carbon dioxide, landfills produce small amounts of H_2S
- H_2S is a marker of a complex mixture of odorant and irritant air pollutants

Research questions and design

- What is the ambient level of H₂S in community bordering a landfill?
- What is the frequency and intensity of reported landfill odor?
- What is the relationship between:
 - H₂S and odor?
 - Odor and changes in daily activities, stress, negative mood states, and irritant and physical symptoms?
- Longitudinal study design of acute outcomes:
 - Adults (≥18 yr) within 0.75 mi of Orange County, NC regional landfill
 - Recorded landfill odor and rated symptoms 2x-daily (morning & evening) for 14 d
 - Concurrently, H₂S recorded in community every 15 min

Single point
monitor
(SPM)



Thermo 450C
SO₂-H₂S analyzer

Analysis approach

- Repeated measures of acute/transient events
- Each participant serves as own control:
 - Time-invariant characteristics
- Fixed effects linear & logistic regression models:
 - Adjusted for time of day (morning/evening) of diary record
- Variability by wind direction:
 - Northerly wind direction (towards community)
 - Otherwise

Twice daily diary – landfill malodor

Day 1: _____ MORNING

Part II. Go inside. Complete Steps 4-7

STEP 4. Record time when timer goes off after 5 minutes outside. Be sure to use the study clock when you record the time.



Record Current Time	Circle AM or PM
_____	AM
	PM

STEP 5. Describe odor when you were outside. During the 5 minutes that you spent outside, did you notice any odor from the landfill? If **no**, check *none*, and proceed to Step 4. If **yes**, check the box that best describes the level of odor from the landfill during the 5 minutes you spent outside, describe what the odor smelled like, and mark whether the odor was continuous or came and went.

None ▼	faint ▼	moderate ▼	strong ▼	very strong ▼		Was the odor continuous or did it come and go?
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Please describe what the odor smelled like.	<input type="checkbox"/> Continuous
						<input type="checkbox"/> Come and go

Twice daily diary – mood states

Day 1: _____ MORNING

STEP 7. Record feelings. How do you feel now? Check the box that best describes how you feel *after spending 5 minutes outside*. Important: If you do not have any of the feelings described below, please mark *not at all*. There should be a box marked for every feeling described in the table.

	not at all ▼	a little ▼	moderate ▼	a lot ▼	extreme ▼
Stressed?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Nervous or anxious?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Gloomy, blue or unhappy?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Angry, grouchy or bad-tempered?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Confused or unable to concentrate?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Active, energetic, or full of pep?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Weary, bushed, or exhausted?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Twice daily diary – physical symptoms

Day 1: _____ MORNING

STEP 6. Record symptoms. Do you currently have any of the following symptoms? Check the box that best describes the extent to which you are experiencing each symptom, if at all. Important: If you do not have a symptom, please mark *none*. There should be a box marked for every symptom listed.

	none ▼	mild ▼	moderate ▼	severe ▼		none ▼	mild ▼	moderate ▼	severe ▼
Excessive cough	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ringing in ears	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Runny nose or congestion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Burning, tearing, or irritated eyes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sore throat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Burning or irritated nose	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Difficulty breathing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Burning or scratchy throat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Loss of appetite	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Skin irritation or redness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Nausea or vomiting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Ulcer or boils on skin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Diarrhea	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Round patches or scaly areas on skin (coin-sized)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Trouble urinating	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	White or moist areas on skin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
General ill feeling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Rash with spots or bumps	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fever or chills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Itching	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Headache	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Other symptom	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Light headed or dizzy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Please describe symptom: _____ _____ _____			

What is frequency and intensity of H₂S and reports of landfill odor?

Demographics of 23 participants

- Median age: 55 yr (18-78 yr)
- 96% African-American
- 48% female
- 61% grew up near landfill

H₂S and odor measures

- 1-h avg H₂S: 0.22 ppb (0–2.30 ppb)
- H₂S present: 586 (72%) diary periods
- Odor reported: 213 (26%) diary periods

:	N (%)
Total no. of diary records	878 (100)
Total no of odor ratings	818 (91)
No odor	605 (74)
Faint odor	103 (13)
Moderate odor	45 (5)
Strong odor	57 (7)
Very strong odor	8 (1)

Is there an association between H₂S and landfill odor?

And is there evidence of variability by wind direction?

	No. of records	1-hour mean H ₂ S (SD)	Beta Coefficient ^a	SE	t-Value
H ₂ S (ppb)	709	0.22 (0.27)	0.30	0.11	2.75
Wind direction (toward community)	105	0.36 (0.36)	0.67	0.19	3.49
Wind direction (otherwise)	588	0.19 (0.24)	0.08	0.14	0.58

*Fixed effects linear regression models adjusted for time of day (morning/evening) of diary record. SD=standard deviation; SE=standard error.

What is the relationship between landfill malodor and symptoms?

Symptom	No. of records	Binary odor OR (95% CI)*
Alteration of daily activities	819	9.0 (3.5, 23.5)
Negative mood states	819	5.2 (2.8, 9.6)
Upper respiratory	820	3.9 (2.2, 7.0)
Mucous membrane irritation	818	3.7 (2.0, 7.1)
Headache	820	3.3 (1.5, 7.4)
General ill feeling	820	2.7 (1.1, 6.6)
Gastrointestinal	820	1.0 (0.4, 2.6)
Active, energetic, peppy	819	0.6 (0.2, 1.5)

*Fixed effects logistic regression models adjusted for time of day (morning/evening) of diary record. OR = odds ratio; CI = confidence interval.

Landfill malodor, air quality and health

- Strong evidence of health & health-related quality of life impacts of landfill malodor in a disproportionately Black community bordering a regional landfill
- Reported odor should be a better measure of the complex mixture of air pollutants from landfill than H₂S measurements
- There could be correlated errors in reporting of odor and symptoms, which may bias effect estimates of the relation between odor and symptoms
- No evidence of generalized over-reporting of symptoms during odor episodes, because some symptoms showed no relationship with odor
- First study to perform concurrent measures of acute exposures and outcomes
- Longitudinal design controls bias from fixed characteristics of individuals (measured or unmeasured)

Impact of landfill odor on health-related quality of life

Qualitative description of changes in daily activities from participants:

“I couldn’t be outside today given the stench from the landfill.”

“I couldn’t sit on my porch, exercise or walk to my neighbor’s.”

“I have to keep all of my windows and doors closed to keep the smell from coming inside.”

“I couldn’t walk my dog around the yard.”

“I had to drive with my windows up because of the smell of the landfill.”

Sharing results with community and governments



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