Global Geographies of Environmental (In)justice : Using GIS to Estimate Populations at Risk

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Presentation Outline

- Research Background: The EJ Movement: From Local to Global contexts)
  - Research Focus: Hazardous Wastes
  - The Global Toxicity Gradient Hypothesis: Push and Pull Factors
- Case Study: Cote D'Ivoire:
  - Location of Hazardous Sites
  - Compilation and Preprocessing of datasets used
- Geospatial Analysis
  - Atmospheric Dispersion modeling (ALOHA)
  - Integration of the plume footprints into ArcGIS
  - Statistical Validation using EJ Indices/Logistic Regression
- Key Findings and Future Directions

Further Reading

- Maantay, J. and McClafferty (2011): Geospatial Analysis of Environmental Health, ***Springer*** Verlag
- Margai, F.M (2010) Environmental Health Hazards and Social Justice**,**
  Earthscan /Taylor and Francis

Research Background

- The Environmental Justice (EJ) movement began nearly three decades ago in a low income minority community in North Carolina.
- Triggered by community concerns about the disproportionate and unfair distribution of environmental hazards in their neighborhoods with potentially crippling impacts on their health.

Background contd.

- Many studies show that residents in the low income, working class, minority and/or indigenous communities remain by far, the ones that are most impacted and unfairly harmed by these environmental hazards.

- They are also the least likely to benefit from environmental remediation, risk compensation, or legislative efforts designed to redress the problems.

EJ background Contd.

- Since then, significant progress has been made toward the elimination of these inequities in the communities.

- Despite the progress, the story of EJ continues to unfold to include new narratives of resource exploitation, toxic contamination and transnational pollution.
- Today, this movement expands well beyond the borders of the United States to encompass both rich and poor economies of the world including egalitarian societies such as Sweden.

The Need for a Global Perspective

- As the global accounts of EJ unfold, there is a need therefore to broaden the conceptual and analytical lens to examine these incidents in Global South, notably communities in African and Latin American countries.

Overarching Goals of this Study

1. Conceptualize the global dynamics of EJ by examining the underlying mechanisms and drivers behind the expansion and cross-border transfers of polluting industries into the poor countries.

2. Showcase the use of Geospatial methodologies to assess the differential patterns of population exposure to these hazards.

What are the factors that underpin these emergent trends

Globalization…Pollution:

Direct connection between the global geographies of EJ and emerging global economic markets.

"*Globalization brings diverse peoples together; but even as it emphasizes the common humanity of mankind (most visibly in the field of consumer behavior) it also underlines differences which often lead to asymmetrical relations, tensions and social stress"(* Stavenhagen, 1999) pp.2

Emergent Threats

1. Outsourcing of industries by Transnational Corporations:

   Systematic transfer of operations and several aspects of their production chains to the developing nations because of the growing economic hurdles and regulations that hinder their implementation in the industrial countries in which their corporate headquarters are located.

Emergent Threats

2. Digital Dumps

In recent years, we have also witnessed an unprecedented increase in the flow of electronic wastes (e-wastes) that are generated and transported from the industrialized countries.

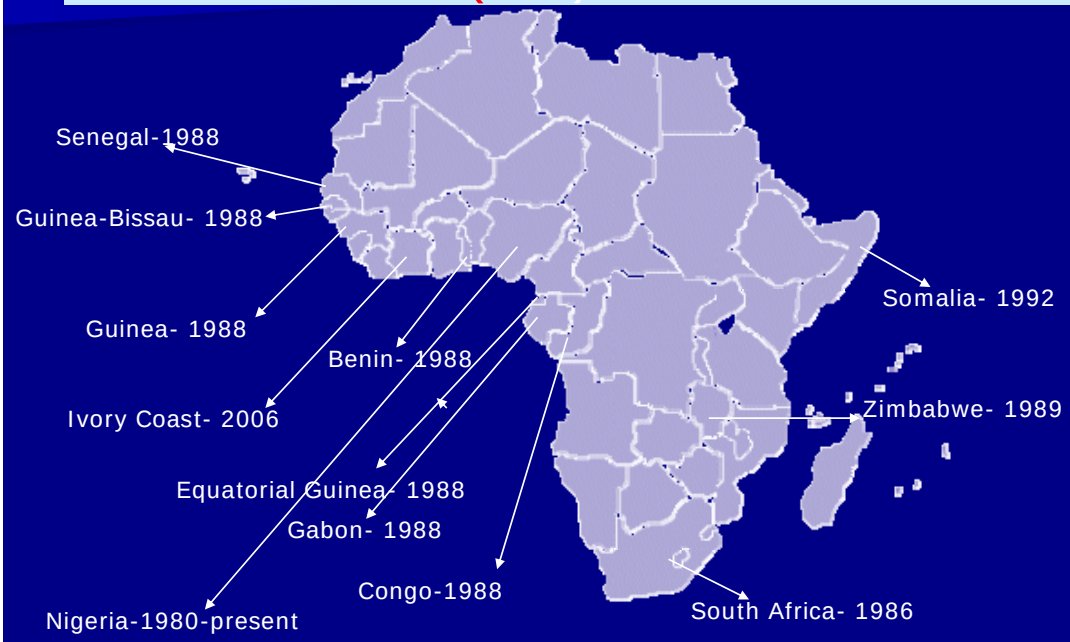
http://news.bbc.co.uk/2/hi/technology/6187358.stm

Agbogboshie Dump, Ghana

Photo Courtesy: Mcconnell, 2009

3. Silent Trade continues

- Despite Multilateral Environmental Agreements (MEAs) adopted to regulate the hazardous trade flows:
- Basel Convention(1992)
- Bamako convention(1998)



Report Incidents of Toxic Dumping in Africa

The Global Toxicity Gradient Push and Pull Factors

Source Countries (Global North)

- Large Volume of Waste produced annually
- Mounting Pressure from environmental groups/NIMBY/NIABY
- Stringent environmental laws
- Rising costs of waste disposal
- Diminishing domestic capacity for disposal of hazardous wastes
- Potential future liability for damages

Global Toxicity Gradient

(Illegal Trade Flows)

Destination Countries (Global South)

- Low production of Hazardous Wastes
- Less Stringent environmental laws
- Low costs of waste disposal
- Market opportunities for materials that can be recovered, reclaimed or recycled
- Limited Opposition from internal groups
- Limited disclosure/mislabeling of wastes
- Limited technical expertise on safe handling or disposal of wastes
- Political instability

Asante-Duah and Nagy, 2001; Gbadegesiin, 2001; Adeola, 2001; McCurdy, 2001; and Lipman, 1998, 2002

Côte d'Ivoire (Ivory Coast)

- Population: 18,013,409 (July 2007 est.)
- Area: slightly larger than New Mexico
- Median age: 19.3 years
- Literacy Rates: 50.9% of the population that is 15 and over is literate
- Ethnic groups: Akan/Kwa (42.1%), Gour (17.6%), Northern Mandes (16.5%), Krous (11%), Southern Mandes (10%) and other (2.8%)
- Religions: Muslim (35-40%), indigenous/animist (25-40%) and Christian (20%)

Source: CIA World Factbook 2007

Source: Asheville Global Report

Cote Divoire

Ivory Coast: mass graves found

The scale of ethnic massacres in Ivory Coast began to emerge yesterday after UN investigators found over 100 dead bodies, some burned alive and others thrown down a well in the space of 24 hours.

Soldiers loyal to Alassane Ouattara drive past people who ventured out looking for water and supplies in Abidjan Photo: AP

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Cote Divoire

News » World News » Africa and Indian Ocean »

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IN NEWS

Source: The Telegraph (april 11, 2011)
http://www.telegraph.co.uk/news/worldnews/africaandindianocean/cotedivoire/8438465/Ivory-Coast-mass-graves-found.html

Ivory Coast Incident: August 19th 2006

Probo Koala Registered In Panama/ Chartered by Trafigura (Dutch Company)

Probo Koala

- Registered in Panama
- Chartered by Trafigura
  - 3rd largest independent oil trader
  - 528 tons of toxics
  - Contends that they are "slops" or wastewater from washing ship tanks
  - Later reports show originate from coker gasoline
  - Initial cost of disposal-500,000 Euros; Negotiated for 18,500 Euros

Pictures provided by: Greenpeace, AFP,NPR

Ivory Coast Incident: August 19th 2006

15 Fatalities
55,000 injuries

Pictures provided by: Greenpeace, AFP,NPR

A sample of dumpsites

Source: Margai, 2010

Analytical Objectives

- To geocode the illegal hazardous waste dumps linked to the August 19th incident in Ivory Coast.
- Sample and Determine the volume and toxicological profiles of the chemicals that were dumped.
- Use atmospheric dispersion-based models to delineate the risk zones for the most dangerous chemicals associated with the incident.
- Conduct vulnerability analysis to profile the socio-demographic characteristics of the at-risk populations.

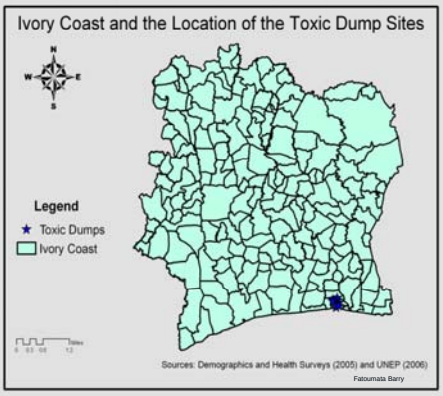
Primary Data Sources

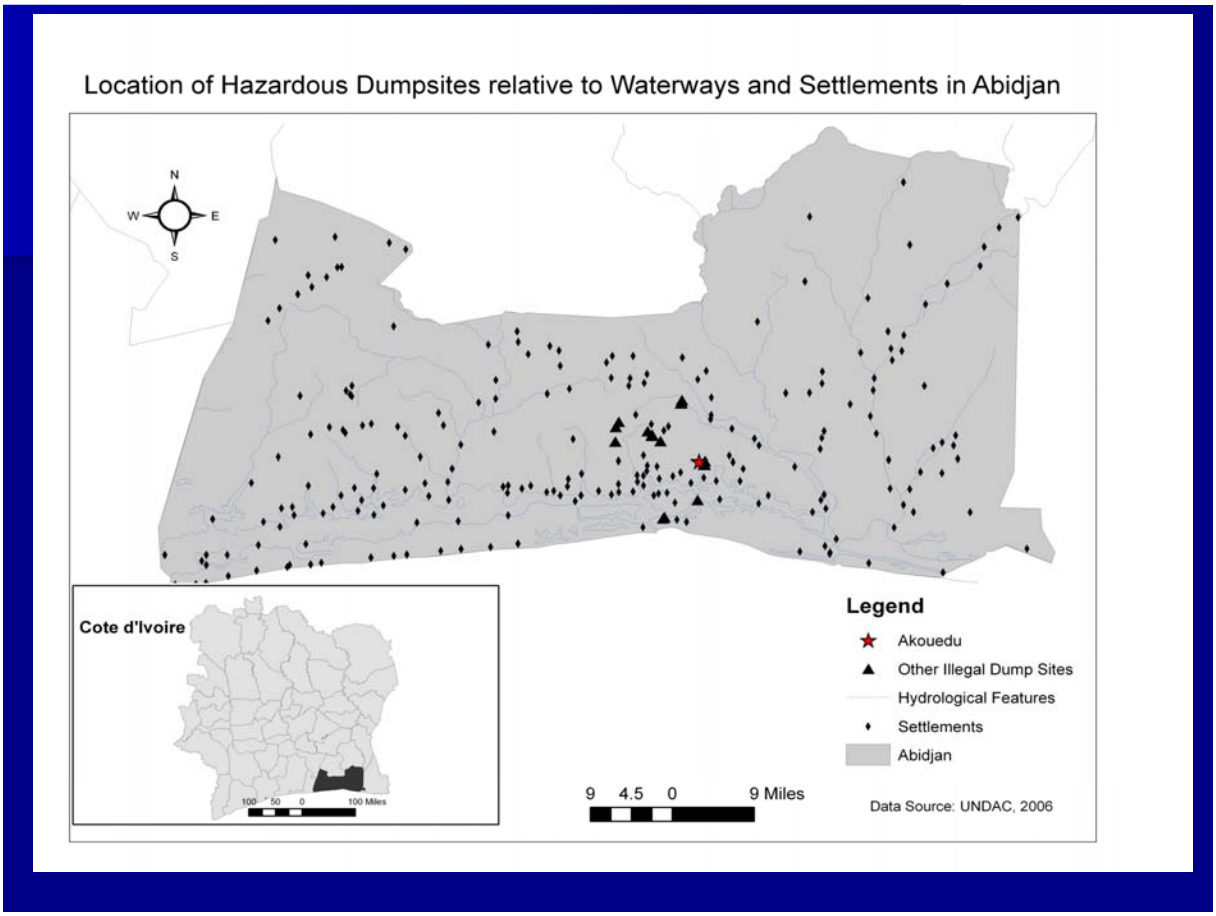
- Demographic Variables: Demographic and Health Surveys (2005)
- Event Reports (Chemicals/Toxic Wastes): United Nations Disaster Assessment and Coordination (2006)
- Toxic Sites: United Nations Environmental Program (2006)
- Weather Conditions: Tu Tiempo (2006)
- Toxicological Profiles: Agency for Toxic Substances and Disease Registry (2007)
- GIS Data Depot (2007): Transportation, Land Cover, Hypsography, Drainage, DEMs

Software Packages

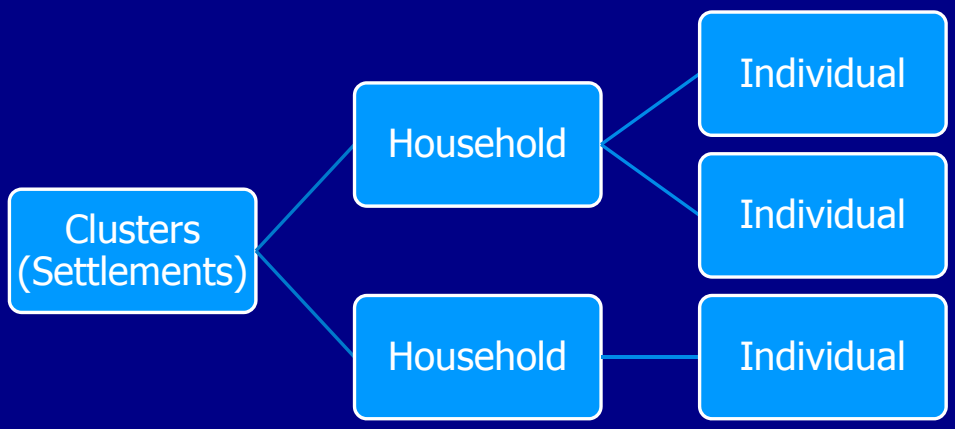
1. Geocoding of accident sites (ArcGIS 9.2)
2. Aggregation of Sampled Demographic Data (SPSS 15.0)
   Geostatistical analysis (Kriging) to spatially predict the demographic patterns at the administrative zone 2 level (ArcGIS 9.2).
3. Atmospheric dispersion models (ALOHA 5.2.3)
4. Vulnerability analysis and mapping (ArcGIS 9.2)
5. Statistical Analysis to identify at risk populations (SPSS 15.0)
   a. Toxic Demographic Difference Index (TDDI)
   b. Logistic regression Analysis

Step 1. Geocoding of Toxic Sites





Step 2. Socio-Demographic Variables (Obtained from DHS, 2005) Sampling Process

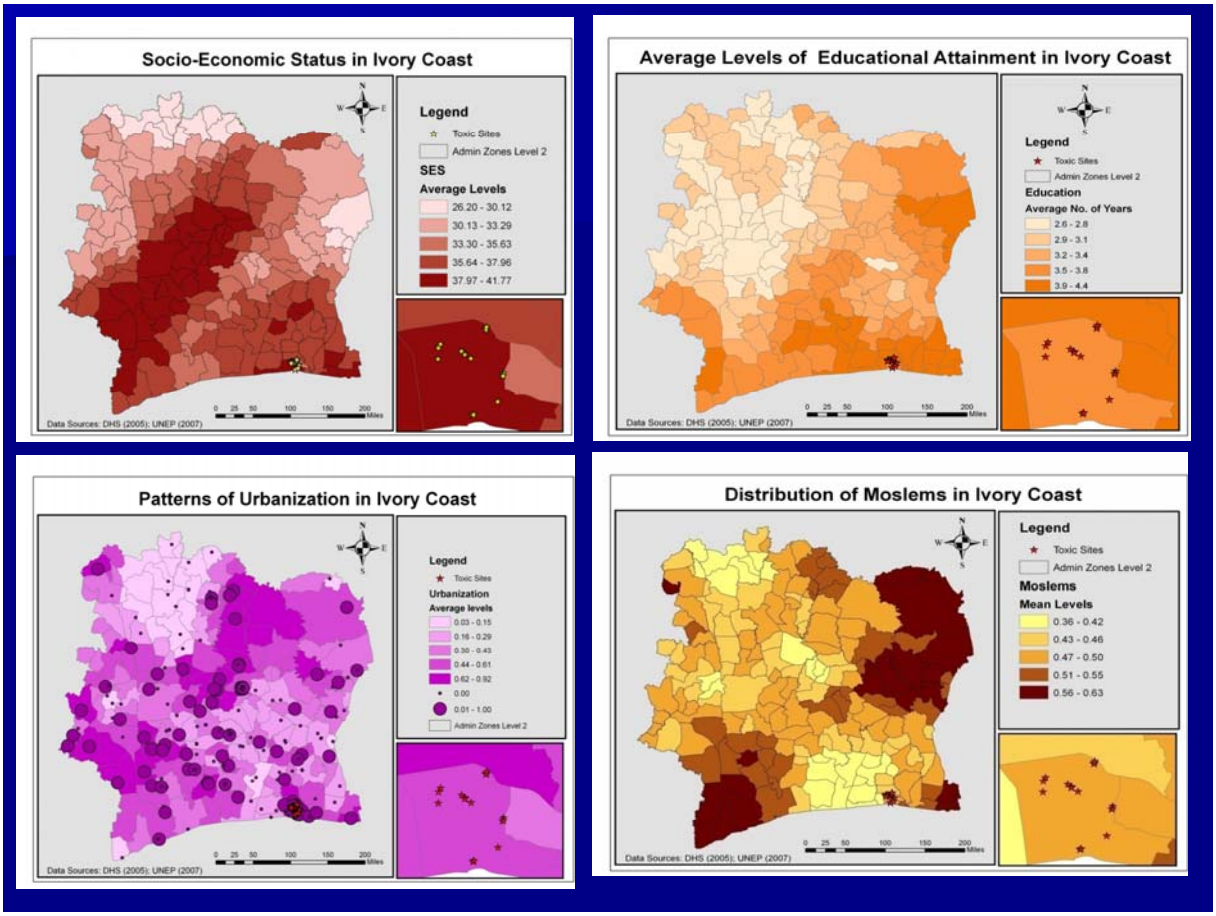


253
(66)

N=9,686
(n =1,708)

Variables Used in the analysis
(from DHS 2005)

1. Patterns of urbanization
2. Age
3. Employment
4. Educational attainment
5. Length of stay in community
6. Socio-economic status (wealth index)
7. Ethnicity (Kwas: Majority, Ahizi : Minority groups)
8. Religiosity (Moslems)
9. Access to basic amenities (piped water, electricity etc)
10. Household Size
11. Number of children



Step 3. Delineating Risk Zones

- Four Major Chemicals:
  - Hydrogen Sulfide
  - Methyl Mercaptans
  - Phenols
  - Polycyclic Aromatic Hydrocarbons (PAHS)

- Health outcomes associated with these chemicals vary:
  - Include respiratory irritations, headaches, burning eyes, skin burns, liver damage, dark urine, irregular heartbeat, anemia, cancer, deaths.

3. Dispersion Modeling Using ALOHA

(Areal Location of Hazardous Atmospheres)

ALOHA 5.4 - [Text Summary]

File Edit SiteData SetUp Display Sharing Help

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SITE DATA:
  Location: AKOUEDO, IVORY COAST
  Building Air Exchanges Per Hour: 0.55 (unsheltered single storied)
  Time: August 19, 2006  1900 hours ST (user specified)

CHEMICAL DATA:
  Chemical Name: HYDROGEN SULFIDE          Molecular Weight: 34.08 g/mol
  ERPG-1: 0.1 ppm     ERPG-2: 30 ppm       ERPG-3: 100 ppm
  IDLH: 100 ppm       LEL: 43000 ppm       UEL: 455000 ppm
  Ambient Boiling Point: -76.6° F
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 5 knots from ESE at 3 meters
  Ground Roughness: urban or forest        Cloud Cover: 5 tenths
  Air Temperature: 25.3° C                 Stability Class: E
  No Inversion Height                      Relative Humidity: 94%

SOURCE STRENGTH:
  Direct Source: 1 tons                    Source Height: 0
  Release Duration: 1 minute
  Release Rate: 33.3 pounds/sec
  Total Amount Released: 2,000 pounds
  Note: This chemical may flash boil and/or result in two phase flow.

THREAT ZONE:
  Model Run: Heavy Gas
  Red    : 1.1 miles --- (100 ppm = ERPG-3)
  Orange: 1.9 miles --- (30 ppm = ERPG-2)
  Yellow: greater than 6 miles --- (0.1 ppm = ERPG-1)
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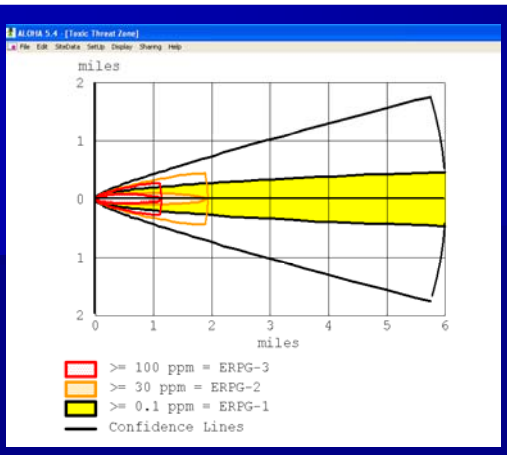
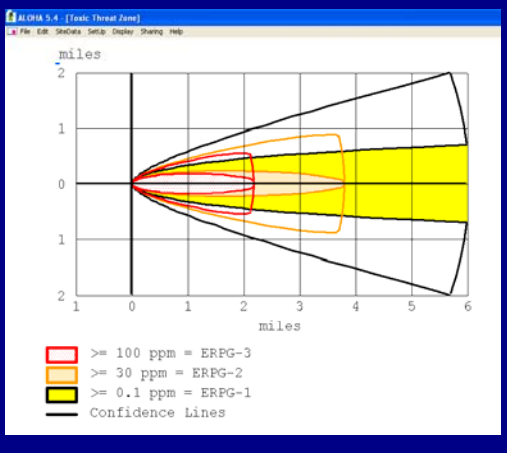




Footprint Window

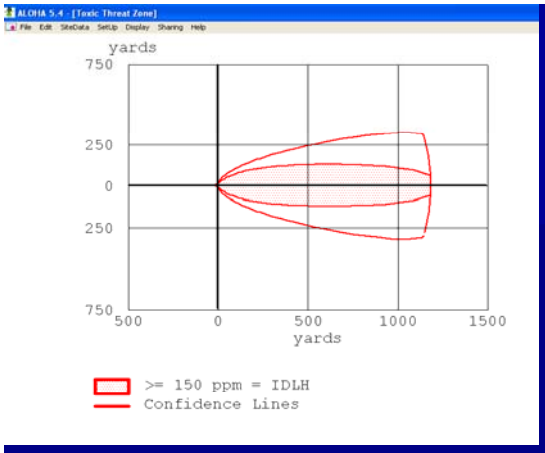
Time: August 19, 2006
1900 hours ST

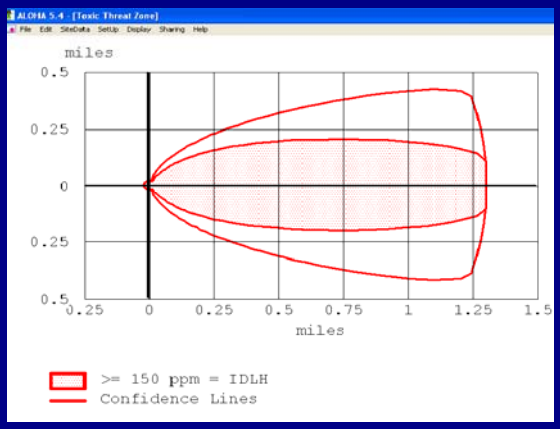
Chemical Name: Hydrogen Sulfide

Wind:5 knots from ESE at 3 meters

FOOTPRINT INFORMATION:

- Model Run: Heavy Gas
- User-Specified LOC: equals IDLH (100ppm)
- 1 ton: Max Threat Zone for LOC: over 6 miles
- 7.75 tons: Max Threat Zone for LOC: over 6 miles





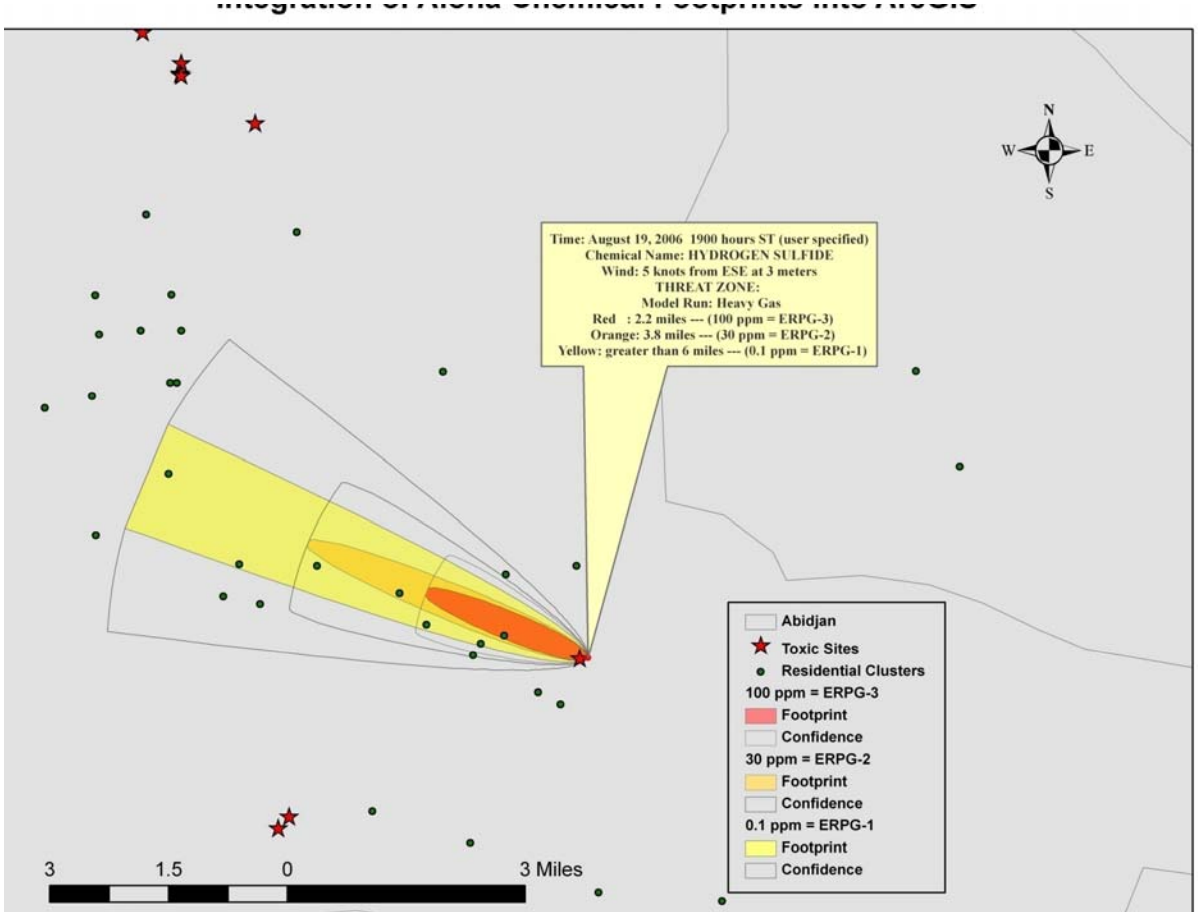
Footprint Window

Time: August 19, 2006
1900 hours ST
Chemical Name: Methyl Mercaptans
Wind:5 knots from ESE at 3 meters

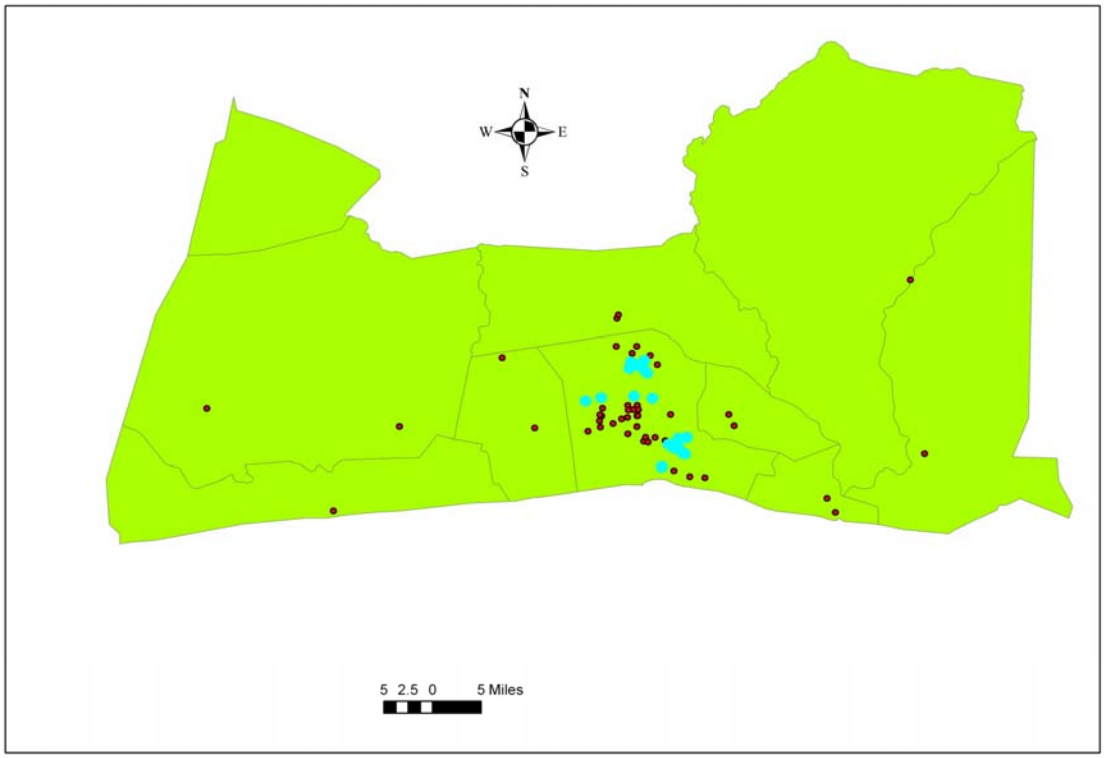
FOOTPRINT INFORMATION:
Model Run: Heavy Gas
User-Specified LOC: equals IDLH (150ppm)

1 ton: Max Threat Zone for LOC: 1,259 yards

7.75 tons: Max Threat Zone for LOC: 1.4 miles



Population Clusters Relative to Illegal Toxic Dumps in Abidjan



5. Toxic Demographic Difference Index (TDDI.....Harner et al., 2002)

Variable	Low Impact $n_1=912$	High Impact $n_2=796$	t test	TDDI *(1-p)*
Age of respondents (years)	27.55	28.12	-1.306	0.806
Length of stay (years)	9.21	17.66	-12.13***	1.00
Kwa (majority) Ethnic group	81.14	80.65	.255	.202
Ahizi (minority)Ethnic group	18.86	19.10	-.124	.099
Employed	60.09	72.24	-5.351***	1.00
Moslem	34.43	52.51	-7.631***	1.00
Access to Piped Water	91.67	55.40	18.255***	1.00
Access to electricity	89.14	45.48	21.355***	1.00
No of household members	7.93	8.97	-4.154***	1.00
No. of Children aged 5 and under	.99	1.48	-7.211***	1.00

****p≤ 0.01 ; **p≤ 0.05*

Variables in Equation	B	S.E	Wald	Odds Ratios
Education (Higher_reference)				
➢No education	.702	.243	8.32***	2.107
➢Primary	.606	.248	5.95**	1.833
➢ Secondary	.440	.233	3.56*	1.553
No of house members***	.043	.013	10.99***	1.044
Access to Piped water	-1.914	.191	100.25***	.147
Access to Flush Toilet	-1.612	.177	43.19***	.313
Wealth Index (Richest-Reference)				
➢Poor	3.640	.348	109.54***	38.089
➢Middle	.304	.212	2.04	1.355
➢Richer	.169	.174	.940	1.184
Length of Stay	.036	.006	41.26***	1.037
Kwa Ethnic group	-.904	.200	20.42***	.405

-2LL=1308.4 Cox and Snell R^2=.438 Nagelkerke R^2 =0.584

****p≤ 0.01 ; **p≤ 0.05 ; *p≤.10*

Results

- Profile of residents in HIZ:
  - Low Educational attainment
  - Working Class
  - Limited Access to water and basic household amenities
  - Lower Socioeconomic status
  - Ethnicity (minority group)

Future Research Directions

- Overall this study reflects a preliminary assessment of the environmental risk zones associated with the toxic incident.
- Using GIS and other analytical tools, we have identified where the vulnerable populations are, and their socio-demographic profiles.
- This is great starting point for exposure assessment and long term biomonitoring of health consequences. This approach eliminates the need for time consuming and expensive measurements across the entire region.

Future Research Directions Contd.

- Next steps include:
- Localized Contextual analysis: more in depth epidemiological analysis of impact areas.
  - Detailed health data for those residing within the hazard risk zones.
  - Longitudinal Data: Biomonitoring of those affected.
  - Ongoing sampling of environmental media (air, water and soil quality).

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