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Development of local knowledge of environmental contamination in Sydney, Nova Scotia: Environmental health practice from an environmental justice perspective

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Abstract

In Sydney, Nova Scotia, from 1901 through 1988 a coke and steel factory operated with no pollution controls, depositing over a million tons of particulate matter and releasing several thousands of tons of coal tar into the estuary. Previously we documented the presence of lead, arsenic and PAHs, in soil above Canadian guidelines, and in house dust in the communities surrounding the site [Lambert, TW, Lane, S. Lead, arsenic, and polycyclic aromatic hydrocarbons in soil and house dust in the communities surrounding the Sydney, Nova Scotia, tar ponds. Environ Health Perspect 2004; 112:35–41.]. In this paper we further the research by documenting and developing community knowledge with a study of resident's observations and experiences of the industrial contamination. We conducted two surveys, a quantitative door-to-door survey and qualitative dust interview, designed to complement each other and bring together the observations and experiences in the different communities to develop the local knowledge. The combined methodology uses techniques from both social and physical science, and was developed with the cooperation of community members. The research supports the proposition that local knowledge adds contextual meaning that complements the physical measurement of environmental contaminants, in order to understand the complex environment in which people live, and the multiple exposure pathways through which they can be affected. Residents in all three communities provided vivid observations and detailed experiences of the industrial pollution in their community and homes. The local knowledge is consistent with our physical data and review of the historical scientific research in Sydney, and supports the inference that the community was adversely impacted by the coke and steel facility. From a justice perspective, the three communities should be equally considered for remediation as part of the 'tar pond remediation policy' rather than the current policy of including only a few streets and houses.

Keywords: Local knowledge; Environmental justice; Qualitative research; Quantitative research; Participatory research; Community-based; Sydney tar ponds; Environmental contamination

1. Introduction

In Sydney, from 1901 through 1988 a coke and steel factory operated with no pollution controls, depositing over a million tons of particulate matter on the surrounding area and releasing >700 thousand tons of

Abbreviations: (As), arsenic; (CCME), Canadian Council of Ministers for the Environment; (Pb), lead; (NOCO), north of the coke ovens; (PAHs), polycyclic aromatic hydrocarbons; (WP), Whitney Pier; (Ash), Ashby; (NE), North End; (H_2S), hydrogen sulfide.

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coal tar into the Muggah creek estuary (Fig. 1) (Furimsky, 2002). In 1998, a memorandum of understanding was signed between the Government of Canada, Province of Nova Scotia and Cape Breton Regional Municipality stating that the Muggah Creek estuary is recognized as Canada's worst contaminated site and should be considered a national issue (CBCL, 1999). Despite this recognition, the communities surrounding the site have not been considered adversely impacted or considered in the tar pond remediation policy. The one exception is a small area 'north of the coke ovens' (NOCO), in Whitney Pier, where limited remediation has taken place on some properties (Fig. 1).

In a previous publication, we found no significant difference in lead, arsenic and polycyclic aromatic hydrocarbons (PAHs) in soil and dust, in the three communities adjacent the industrial site (Lambert and Lane, 2004). In this paper we further the research by documenting and developing local knowledge with a study of the residents' observations and experiences of the industrial contamination. The combined methodology uses techniques from both social and physical science, and was developed with the cooperation of community members. In this respect it contributes to the development of community-based or participatory research (O'Fallon and Dearry, 2002; May et al., 2003) and environmental health theory and practice which is grounded in the convergence of these different paradigms (Parkes et al., 2003; Corburn, 2002a).

The research is also a contribution towards the development of methods in environmental health practice that respects a 'science of environmental justice'. Coughlin (1996) discussed the emergence of environmental justice and disproportionate exposure to environmental contaminants in disempowered communities. Coughlin suggested that scientists can protect and restore health in disempowered communities by undertaking studies to clarify the extent to which communities have been exposed to toxic wastes. Wing (2005) stated "a science of environmental justice is a science for the people, applied research that addresses issues of concern to communities experiencing environmental injustice, poor public health conditions and lack of political power" (Wing, 2004, p. 61).

In the 'traditional science' paradigm, scientists stand detached from the community, which is viewed primarily

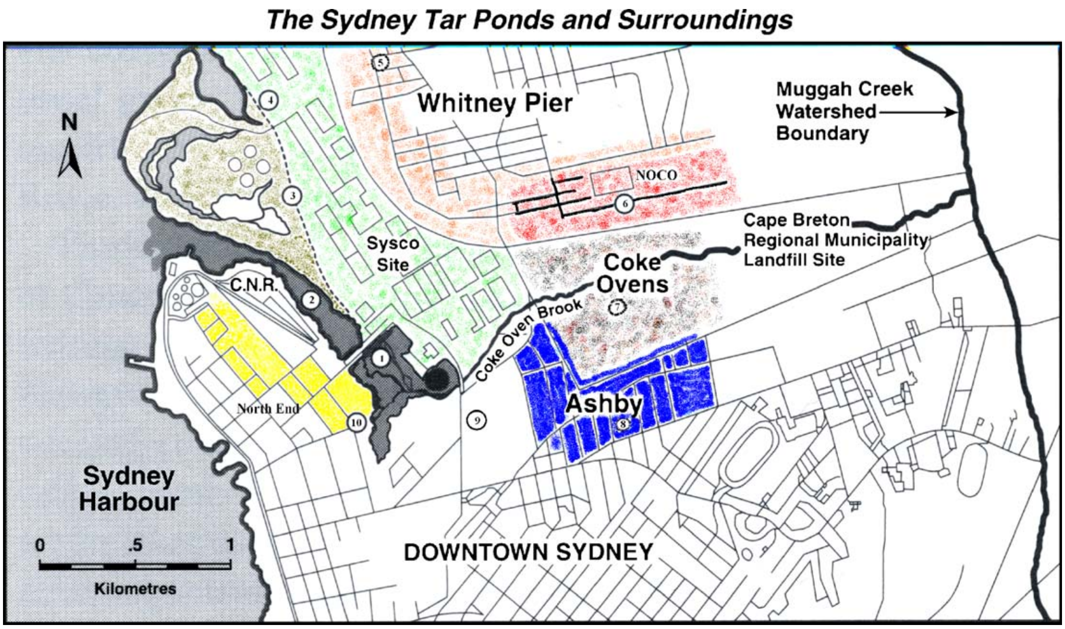

Fig. 1. Sydney tar ponds and surrounding area (adapted from Barlow and May, 2000). The two surveys took place in the coloured area of the three communities, North End in yellow, Ashby in blue and Whitney Pier in orange and red. In Whitney Pier, an area called north of the coke ovens (NOCO), red with bold streets has been partitioned off from Whitney Pier as a whole. This study tested the assumption that Whitney Pier is different than Ashby and North End. Legend: 1. The north tar pond. 2. The south tar pond. The tar ponds are reported to contain 700,000 tons of coal tar of which 50,000 tons are contaminated with PCBs, however, the amount of coal tar may exceed this estimate by many times (Furimsky, 2002). 3. The original water line that intersects the Sysco site; the infill material is predominantly slag piles. 4. The hazardous waste incinerator built in 1992 to burn the coal tar waste in the tar ponds. 5. The Whitney Pier Memorial Junior High School is situated approximately 600 m up the hill from waste incinerator. 6. The NOCO area of Whitney Pier is red and the specific streets are bold. The entire shaded area of Whitney Pier was sampled. 7. The coke ovens site where 400 coke ovens processed coke for the steel mill. 8. Ashby sampling area in light blue. 9. The Don Bosco school. 10. North End sampling area in yellow.

as the subject or object of their study. The assumption underlying this relationship with the community is perhaps the idea that science should be conducted from a disinterested perspective in order to be 'objective' (Wing, 2003). In contrast, science from an environmental justice perspective implies that science is conducted within a relationship with the community. In the relationship, scientists 'foster autonomy through mutually respectful relationships'; scientists 'being for' the community to foster the community's evaluation of their concerns (Lambert et al., 2003). Scientists are engaged with the community to help them articulate and to research questions they formulate with the scientists to address environmental and public health policy questions.

The relationship implies developing an understanding and appreciation of the questions which current scientific methods may be able to address. Similar to that described by others (Corburn, 2002a; O'Fallon and Dearry, 2002), the relationship in our study is asymmetrical: scientists bringing methods and scientific knowledge, the community bringing their specialized knowledge of the environmental conditions, and their particular lived experience in the environment. The community and scientists jointly formulate the relevant hypotheses; the research conducted by the scientists is 'informed' by local knowledge.

This does not mean that knowledge claims arising from environmental justice science are any less capable of making 'objective' claims, i.e., independent of what anyone feels about the matter, than those from traditional science. For example, the measured soil concentrations of lead, arsenic, PAHs among other contaminants in Sydney are independent of what a scientist may feel about the matter. However, the meaning of the concentrations and what questions are asked about their presence involves extra-science values.

Science from an environmental justice perspective is also not necessarily biased compared with 'traditional science'. In fact, the struggle to limit bias is similar for 'traditional science', where research and research institutions are funded by government and corporations. There are concerns that this research is biased towards the values or perspectives of government and corporations (Wing, 2003; Sass et al., 2005; vom Saal and Hughes, 2005). This clarifies that the contrast between 'traditional science', which addresses concerns or interests of others, and environmental justice research, which addresses concerns of particular communities, does not necessarily refer to the actual validity of scientific methodology. The bias that may enter science from the cultural context and social forces is perhaps mitigated in environmental justice science by explicitly acknowledging and including the cultural/social context of the research (Wing, 2002).

Further the fiduciary responsibility of the environmental justice scientist is to develop knowledge with the community that is methodologically rigorous and leads to 'objective' claims. From an ethical perspective, the community places trust in scientists that the research is methodologically sound, addresses their concern, and that the science will not lead to 'biased' conclusions which clearly have a significant potential of harming the community; and of particular concern, suggesting there are no health risks when in fact there are. In this respect, the responsibilities on scientists to address bias are greater as they actually face the community within a fiduciary relationship, i.e., the community places trust in the scientists to conduct rigorous scientific research. This brings out a key distinction in that the relation between the community and scientist within the environmental justice perspective approaches a health-care relationship grounded in fostering autonomy as opposed to 'traditional science paradigm' where the scientist stand-point is 'detachment'.

An important part of the development of environmental justice theory is the question of local knowledge as a complement to more traditional scientific data-gathering techniques. Corburn (2002b) stated that a primary critique of health research methods from an environmental justice perspective is that: "institutionalized risk discourse — often termed risk communication and management — has systematically excluded local, non-expert knowledge by creating hard boundaries between scientific analysis and political values, and between expert and lay judgments" (Corburn, 2002b, pp. 451).

Respecting environmental justice in environmental health practice requires getting beyond the dichotomy created by considering 'local knowledge' as being distinct from more specialized scientific knowledge. This paper is a contribution to this specific issue as part of the development of a science of environmental justice. We provide research to support the proposition that local knowledge adds contextual meaning that complements the measurement of environmental contaminants, in order to understand the complex environment in which people live, and the multiple exposure pathways through which they can be affected.

Concerns of community members arise from their 'perception' that the coke and steel facility impacted their community and health. These were first documented by Dr. Morris Katz of Canada's Department of National Health and Welfare in 1956. Katz and McKay (1959) stated "complaints by people living in the northeastern part of the city concerning the deposition

Table 1
Survey questions

Door-to-door survey: closed
1. a) Does/did your child ever play in any of the following sites:
1) steel mill?
2) coke ovens?
3) slag piles?
4) tar ponds?
5) municipal and industrial land fill site?
6) Muggah creek, coke ovens brook, or other streams and ditches around the above sites?
2. If yes, how often does/did they play in these areas?
1) once per day?
2) once per week?
3) once a month?
4) on occasion?
3. Did you ever smell odours in your neighbourhood?
4. Please describe the smells and the years and duration of occurrence?
1) kerosene
2) tar
3) coal
4) mothballs
5) rotten eggs
6) solvent
7) weak gasoline.
5. Did you ever notice these inside your home?
6. Did you ever observe ash, soot, dust, smoke or other particulates in your neigbourhood?
7. Please describe the thickness, colour, source and the years and duration of the occurrence and the residence at which you were living at the time.
Thickness:
1) light
2) medium
3) heavy.
8. Did you ever observe this pollution inside your home?
Dust study survey: open
1. Did you live at these premises when the coke ovens or steel plant were in operation?
2. Did you ever notice smoke from the coke ovens or steel plant coming into your home?
3. How often per week or month did you notice coke/steel smoke come into your home?
4. Did you notice any seasonal variation in the smoke?
5. Did you notice odours from the coke ovens or steel plant in your home?
6. How often per week or month did you notice odours in your home?
7. Did you notice any seasonal variation in the odours?
8. Were you employed at the coke ovens or steel plant
9. Is there any other information about potential sources of the contaminants that you would like to provide?

of dust from the blast furnaces of the Dominion Steel and Coal Corporation coincided with the introduction of Labrador iron ore, along with Wabana ore, in the charge furnace" (Katz and McKay, 1959, pp. 1). Foreshadowing environmental justice science, Katz initiated an air monitoring program in Sydney in the late 1950s which documented significant dust deposition in all three communities surrounding the site validating the residents concerns. Recently, Barlow and May (2000) documented resident concerns about the seepage of contamination into their homes along Frederick Street, in NOCO.

Our 'social study' supports our physical study (Lambert and Lane, 2004), by developing the local knowledge in all three communities surrounding the site. Two community surveys were conducted within a three block area around the site in the same geographical area as our soil and dust study: a quantitative door-to-door survey and a qualitative interview done during the soil and dust sampling. The observations gathered in the dust interview were designed to complement the quantitative data collected in the door-to-door survey. We compare observations of odour, smoke, and ash deposition in the three communities. The local knowledge developed from both surveys provides for a contextual understanding of the physical data. In the discussion we develop the proposition that local knowledge provides contextual support for our physical data, and the historical scientific knowledge of contamination, in evaluating the hypothesis that there is no significant difference between Whitney Pier and the two control communities.

2. Methods

2.1. Quantitative door-to-door survey

Residents within a three block radius of the site were contacted to complete a detailed questionnaire with respect to health and local knowledge. There were ~1100 homes in the target area. Residents were contacted door to door for participation over a 4 month period and an attempt was made to contact all homes. 325 households participated in the survey in Whitney Pier ($n=138$), Ashby ($n=105$) and North End ($n=82$). There were no refusals to participate, and the main reason for non-inclusion was the difficulty in contacting residents as well as arranging 2 h to conduct the full survey. The surveys were administered by local community members, who were trained and paid a small fee. Seven questions in this questionnaire were analyzed, from respondents who were present during the emissions, dealing with knowledge of odours, smoke presence and colour, ash, observations within the home, and children's activity on the contaminated sites (Table 1). The questionnaire was closed; residents selected from a list of responses.

2.2. Qualitative dust survey: 'dust interview'

During the physical dust study, an interview was completed with participating residents (Lambert and Lane, 2004) (Table 1). A stratified random sample of 15 homes in each of the three neigbourhoods surrounding the industrial facility was chosen to ensure coverage of the entire area. This dust interview provides knowledge from residents who lived in the community while the industrial facilities operated: Whitney Pier ($n=15$), Ashby ($n=13$) and North End ($n=13$). Questions provided structure for an interview with the residents and ensured the same set of questions were asked (Table 1). The interview was open; residents were not provided with potential responses.

2.3. Data analysis

The responses in the door-to-door survey and dust survey were coded and entered into the Statistical Package for the Social Sciences (SPSS). Frequency distributions and two-way cross tabulations were used to analyze the data, and Pearson chi-square or Fisher's Exact Test, two-sided, was calculated to determine differences in the three communities.

2.4. Member validation

This research was designed in dialogue with the community. The community desired research to address their concern that their community had been impacted by the emissions from the coke and steel plant, and that their health may have been affected. In this dialogue, the soil and dust study were proposed, along with the local knowledge aspects of the door-to-door survey and interview during the dust study to show the impact of the emissions on the community. Brown (2003) suggests that research should have member validation. The results of the survey and interviews have been presented at two public meetings of the 'People's Health Commission' (PHC) meetings; PHC is the name of our expert and local group. In addition, versions of the paper have been read and critiqued by members of the community.

2.5. Historical knowledge

Residents provided us with many of the government scientific studies and information is available on the community website (www.safecleanup.com). The Environment Canada, university and public libraries were searched for papers on the tar ponds, but some documents appear to be lost.

3. Results

3.1. Door-to-door survey

3.1.1. Smoke

The most frequent colour of smoke seen by residents was black and orange (Table 2). This was the only 'open' question in the door-to-door survey and the results were grouped by main colour reported. There was a significant difference between Whitney Pier and the control communities in reporting 'red smoke' (chi sq. = 0.013). For all other colours there was no statistical difference.

Table 2
Observation and colour of smoke perceived in the door-to-door survey

Colour of smoke	Answer	Whitney Pier		Ashby		North End		Pearson chi-square asy. sig.
		Count	Col %	Count	Col %	Count	Col %	
Black	No	91	65.5	78	71.6	70	72.9	0.404
	Yes	48	34.5	31	28.4	26	27.1	
Grey	No	124	89.2	98	89.9	81	84.4	0.413
	Yes	15	10.8	11	10.1	15	15.6	
Orange	No	100	71.9	86	78.9	72	75	0.455
	Yes	39	28.1	23	21.1	24	25	
Yellow	No	134	96.4	106	97.2	96	100	0.186
	Yes	5	3.6	3	2.8	0	0	
Red	No	118	84.9	104	95.4	89	92.7	0.013
	Yes	21	15.1	5	4.6	7	7.3	
Silver	No	134	96.4	105	96.3	92	95.8	0.972
	Yes	5	3.6	4	3.7	4	4.2	
Other colours	No	129	92.8	103	94.5	93	96.9	0.406
	Yes	10	7.2	6	5.5	3	3.1	
Observe smoke, soot, ash	No	8	9.3	13	25	6	12	0.033
	Yes	78	90.7	39	75	44	88	

Table 3
Observation of ash in each community in the door-to-door survey

Ash	Response	Whitney Pier		Ashby		North End		Pearson chi square
		Count	Col %	Count	Col %	Count	Col %	
Observed ash in neighbourhood	no	7	8.1	8	15.4	4	8	0.33
	yes	79	91.9	44	84.6	46	92	
Light		13	15.9	4	8.7	9	19.6	0.01
Medium		14	17.1	7	15.2	18	76.1	
Heavy		55	67.1	35	76.1	19	41.3	
Medium–heavy		69	84.1	42	91.3	37	80.4	0.33

Most respondents reported "ash, soot, dust, smoke, or other particulates" in their neighbourhoods, although the percentage was slightly lower in Ashby (~90% in Whitney Pier and North End vs. 75% in Ashby, $p=.033$).

3.1.2. Smoke, soot, and ash deposition

Respondents (>80%) suggested there was medium to heavy deposition of smoke, soot, and ash (Table 3). In Whitney Pier and Ashby most of the respondents suggested the ash deposition was heavy whereas in North End, the responses were split between medium and heavy deposition. The communities were statistically different in reporting light, medium and heavy ash deposition (chi sq. = 0.01). If the medium and heavy categories are combined there is no difference in the communities (chi sq. = 0.33).

3.1.3. Odour

Over 86% of respondents reported smelling odours (Table 4). There was no significant difference between the communities (chi sq. = 0.64). The predominant odour was rotten eggs (40–50%) and there was no significant difference between the communities in reported rates of rotten eggs, coal and tar odour. Few respondents reported kerosene, solvent, mothballs, and weak gasoline (<6%).

3.1.4. Pollution indoors

For those that reported observing pollution and odour, a large number reported ash and smoke indoors (>60% of residents) and odour indoors (>68% of residents) (Table 5). There was no significant difference between the communities.

3.1.5. Children playing on the contaminated sites

More parents in Whitney Pier (27.2%) than Ashby (14.1%) and North End (16.7%) reported their children had played on the contaminated sites (Table 6). However, there were no significant difference between the communities (chi sq. = 0.076). This question is different than the others in that it captures people who resided in the community both before and after the

Table 4
Odour observations in each community in the door-to-door survey

Odour	Response	Whitney Pier		Ashby		North End		Pearson chi square
		Count	Col %	Count	Col %	Count	Col %	
All odours	No	13	14.1	6	10.3	5	9.4	0.64
	Yes	79	85.9	52	89.7	48	90.6	
Rotten eggs	No	56	60.9	27	47.4	31	59.6	0.24
	Yes	36	39.1	30	52.6	21	40.4	
Tar smell	No	66	71.7	44	77.2	37	71.2	0.71
	Yes	26	28.3	13	22.8	15	28.8	
Coal smell	No	77	83.7	47	82.5	48	92.3	0.27
	Yes	15	16.3	10	17.5	4	7.7	
Kerosene	No	86	93.5	56	98.2	49	94.2	0.41
	Yes	6	6.5	1	1.8	3	5.8	
Solvent	No	89	96.7	57	100	52	100	0.17
	Yes	3	3.3	0	0	0	0	
Mothballs	No	89	96.7	57	100	52	100	0.17
	Yes	3	3.3	0	0	0	0	
Weak gasoline	No	90	97.8	52	91.2	52	100	0.03
	Yes	2	2.2	5	8.8	0	0	

Table 5
Pollution and odour moving indoors in the door-to-door survey

Odour	Response	Whitney Pier		Ashby		North End		Pearson chi square
		Count	Col %	Count	Col %	Count	Col %	
Ash, smoke, dust indoors	No	26	29.9%	17	30.4%	23	41.8%	0.29
	Yes	61	70.1%	39	69.6%	32	58.2%	
Odour indoors	No	26	31.7%	13	26.0%	15	31.3%	0.77
	Yes	56	68.3%	37	74.0%	33	68.8%	

closure of the industrial facility and reflects current and previous child activity.

3.1.6. Demographics

The average age of the survey respondents was 54.9, and 40.9% were over 60 years old. Of the 342 who reported gender, 200 (58.5%) were female and 142 (41.5%) were male. No statistically significant differences were seen for age and gender between the three communities. In Ashby and North End, the population was composed of largely European ethnic backgrounds (>95%). In Whitney Pier there is a relatively large African/Caribbean ethnic community (17%) and this difference was statistically significant (chi square $p<0.001$). Each community has a few people of indigenous ethnicity.

3.2. Dust interview

The responses in the dust interview were coded and quantified (Table 7). The residents' observations in the interview are presented in full for smoke and pollution (Table 8) and odour (Table 9) to provide the contextual data to complement the door-to-door survey results. The resident responses are presented in full to capture their language, and mitigate stripping the meaning from the particular narratives that provide insight into the lived experience and local knowledge.

3.2.1. Smoke

Most interviewed reported smoke in their community or home (Table 7). Approximately 66% of residents indicated smoke was present daily or all the time, however, many responded the presence of pollution was dependent on wind direction (Tables 7 and 8). Most interviewed (33/41) suggested there was no seasonal variation in the smoke; those that did suggested summer appeared worse. A variety of colours were reported: orange haze, black, yellow, and white quencher smoke (Table 8). Curiously, in the interviews in Whitney Pier, only a few residents suggested colours of the smoke.

3.2.2. Ash and soot deposition

Respondents in all three communities remarked that the emissions impacted their homes, cars, and laundry (Table 8). Only residents of North End remarked that their windows were damaged from the emissions. Several residents mentioned tiny silver pieces of metal in the emissions, and one resident north of the steel plant showed us tiny silver pieces of metal in the soil outside their home. No resident used the word "ash" to describe the deposition but instead used descriptors such as dust, ore dust, coal dust, dirt, or fall-out. None of the respondents suggested any pollution source other than the industrial operations and tar ponds. In particular, none of the respondents suggested burning of coal in residential furnaces or lead paint as sources of pollution.

Table 6
Children playing on the contaminated sites in the door-to-door survey

	Response	Whitney Pier		Ashby		North End		Pearson chi square
		Count	Col %	Count	Col %	Count	Col %	
Played on industrial sites	No	75	72.8	61	85.9	50	83.3	0.076
	Yes	28	27.2	10	14.1	10	16.7	
Steel mill	Yes	11	39.3	5	50	2	20	0.21
Coke ovens		6	21.4	1	10	5	50	
Tar ponds		11	39.3	3	30	2	20	
All		0	0	1	10	1	10	

3.2.3. Odour

There were no differences between the communities for reporting odour (>90%) (Table 7). In the interviews, respondents described a complex mixture of odours, sometimes sulfur smell, but predominately rotten eggs (Table 9). In each community, ~50–60% of respondents suggested an odour of rotten eggs (Table 7). A resident (SW-10) in Whitney Pier suggested a particular chemical: "Bad odours when bleeding the battery, hydrogen sulfide, rotten egg smell; and various other smells". However, perhaps the smell was beyond description as suggested by one respondent (SW-28): "can't describe the smell; smelled like work for the people".

3.2.4. Pollution indoors

Many of the respondents suggested that the pollution had moved into their home (Table 8). For example, SW-11 in Whitney Pier said: "if windows open the coal dust would come in the house; could write name in the dust". Similarly, SW-13 in North End said: "when dusting notice the ore dust". Residents in the dust interview said they smelled odours in the house. For example In Whitney Pier, one respondent (SW-29) said: "Yes, odours in the house when the plant was running, like rotten egg like smell".

3.2.5. Children playing on contaminated sites

A few residents provided knowledge of child specific exposures. SW-44 in Ashby described how the children would play 'hide and seek' in the white quencher smoke. SW-4 indicated that the "children used to play on the coal piles". SW-28 commented about the fine metal: "Graphite from coke ovens, little silver pieces outside, the children looked like they had sprinkles on their face". With respect to understanding exposure, the concept of 'personal cloud', was invoked by one resident (SW-42) through a memory of their childhood: "Clothes always smelled — mother used to ask if we were smoking".

Table 7
Descriptors associated with resident responses to dust survey

Descriptor	Whitney Pier	Ashby	North End
Smoke from coke or steel plant come into your home? (Yes)	14/15 SW-23 (No)	13/13	13/13
How often per week or month?			
— Smoke depended on the wind	6/15	7/13	6/13
— Daily basis	5/15	5/13	3/13
— All the time	5/15		7/13
Seasonal variation of smoke? Yes	1/15	2/13	4/15
Odour from coke or steel plant come into your home? (Yes)	15/15	11/13 SW-4 (not in house) SW-18 (No)	12/13 SW-25 (can't recall - now sewage)
How often per week or month?			
Daily/all the time	8/15	2/13	2/13
Seasonal variation of odour? (yes)	2/15	2/13	4/13
— Rotten egg odour	7/15 =47%	8/13=61%	7/13=54%
— Sulphur	7/15	3/15	2/15

4. Discussion

This paper develops the local knowledge related to industrial contamination in Sydney to support the proposition that local knowledge provides contextual support for our physical data. The research brings together the observations and experiences in the different communities, which collectively develop the local knowledge. We use the term 'develop' along the lines of a photographic metaphor where our research 'develops the picture' of the local knowledge in the three communities. Specifically in our context local knowledge informed the formulation of the hypothesis for the physical study of soil and dust contamination (Lambert and Lane, 2004), this local knowledge study, and their relevance to the tar pond remediation policy. However, local knowledge about the pollution has not been systematically captured or collected. Our research brings together people's individual observations about the pollution into a picture, however hazy, and shows the coherence in the three communities surrounding the site. This is the meaning of 'develop the local knowledge'.

To avoid divorcing the data from their local origins, we have presented the words of the residents as closely as we were able to transcribe during the interviews (Tables 8 and 9). From a methodological perspective, the context of the dust study interview is important to understanding the local knowledge presented. We initially took the dust wipe samples. While we were physically taking the dust wipe samples, we spoke informally with the residents, answering their questions about our research. We then asked the interview questions. The words presented here are the short

Table 8
Observations of pollution in the home in the dust survey

Community	Identifier	Observation
Whitney Pier	SW-9	Yes all the time, even coal dust; all the time, when dusting it was always black.
	SW-10	Yes; before we changed sliders, needed to use Q-tips to clean the window sliders of the coke dust.
	SW-11	Yes, if windows open the coal dust would come in the house; could write name in the dust; coal dust, if clothes on the line, the coal dust would cover clothes.
	SW-12	Sometimes a couple times per day, sometimes per week.
	SW-14	Lately it is dust from the steel plant since they are cleaning; road dust is coming from the plant
	SW-15	Dirt and dust could not keep it out; get on clothes; even when windows closed it would get in. With the remediation, where is the new dirt from? Taking contaminated dirt and leaving it in the community; the contaminated dirt is in the air from the remediation — can see the dust in the air, there is no mitigation; I'm concerned for people with lung problems.
	SW-29	Yes, all the time, coal dust, fine black particles; all year round, needed to clean everyday of the week.
	SW-31	Yes, clouds of smoke, depending on wind it could be everyday; noticed pitting on the car, fine like sand, silver, maybe dusty brown, but glare in some, couldn't just wipe off.
	SW-39	All kinds; red ore dust from the open hearth; could see it from the causeway, 4 h away; black smoke from the tar plant.
Ashby	SW-1	You used to see little black spots on the car like grease which would smudge. When they knocked the by-products building down, just painted the patio and noticed black soot within an hour, smudged like creosote. There was no warning of the demolition.
	SW-4	Used to bring the clothes in; every time the wind blows, the dust from the coal piles used to blow in the home; children used to play on the coal piles.
	SW-5	Steam when quenching the coke; dust from coal bank that was stored by the property; everyday depending on the wind. No idea what the contamination could be from, we had so many sources it could be from all of these.
	SW-6	Notice them come to area; used to ride bikes up to the old dump, and the brook had a colour like gold.
	SW-7	Definitely, every time they went to quencher with east wind, blew onto the house; every Sunday when bleeding the battery then orange haze released; noticed black spots on clothes on cars, fall-out.
	SW-19	Always on the clothes when washing, frequently.
	SW-21	Yes orange smoke.

Table 8 (*continued*)

Community	Identifier	Observation
	SW-28	Graphite from coke ovens, little silver pieces outside, the children looked like they had sprinkles on their face.
	SW-44	They used to clean the ovens when there would be no wind and it would settle down on their clothes. You couldn't put your clothes out in the summer unless you knew what time they were cleaning the ovens because there would be orange dust on the clothes. Remember growing up and the smoke from the quencher would come in your bedroom window at night, super white smoke, every night the wind blew this way. The quencher was located right beside the benzene tanks — gas and fire are built beside each other. Lots of black dust floating around in the summer because it was warm, everything was usually done in summer. Quencher went every 15–20 minutes, train went through and would dump water on it. When there was very little wind, the kids played in the field where the white steam from the quencher was because it hid you so that you couldn't see anyone. Remember kids playing hide and seek in the quencher smoke.
North End	SW-13	When dusting noticed the ore dust.
	SW-24	Yes, orange smoke; sometime in the morning there would be silver metal slivers in the air; whenever the wind blew this direction orange smoke. Noticed when left the area the air was so much better elsewhere; when reached Kelly's Mountain [outside of Sydney], could see Sydney was an orange mushroom.
	SW-25	Yes, needed to clean lawn chairs and clothes daily; trains also produced smoke; when the coke plant closed noticed a change in the dust and when the trains stopped noticed a change in the air again.
	SW-26	Yes, lots of dirt, would wash down front of the house, take one week to be black again; notice when the prevailing winds come in this direction, need to wash everything off every day or so. Under the roof wall, it would get very dirty; at the plant they would schedule things do that were very smoky at night.
	SW-32	Yes, some days could not put the wash out; whenever the northwind blew this way the smoke would come here; notice the ore dust
	SW-34	Yes all kinds black and rust colour — in the morning the whole city used to be covered in smoke. Wasn't as bad in the winter; windows were scummy on the side facing tar ponds — could not get the scum off the windows.
	SW-35	Yes pretty bad, always in the area, the windows were smoked; had to keep the windows closed scum on the outside; smell of oil outside sometimes.

(continued on next page)

Table 8 (*continued*)

Community	Identifier	Observation
	SW-36	Yes, sometimes when the wind blew this direction; little shiny pieces of dust. Steel plant ruined the window panes, developed a scum, still can't get them clean.
	SW-41	The siding is stained, the snow used to be coated black; the siding is all rusty colour; when carpet in the hall way, the black tar used to be stuck on the carpet. Shampooing the carpet used to bring the tar up, such that you needed to do this two or three times to get the carpet somewhat decent. You needed to do this every four months. The children used to play in the yard and get black tar on their clothes; it was like soot or something

answers people provided to the interview questions, while we typed the responses into a computer. To some degree, our sitting at the computer, typing their words as they spoke, may reflect the length of the responses and the choice of words to express their recollection of the pollution.

The local knowledge covers the approximate area of impact in the dustfall studies (Katz and McKay, 1959), PAH monitoring (Atwell et al., 1984), and soil and dust study (Lambert and Lane, 2004). The physical and local knowledge inform each other, and provide the ground for inferring whether the communities were adversely impacted by the industrial emissions.

The quantitative door-to-door survey and qualitative dust interview were designed to complement each other and bring together the observations and experiences in the different communities to develop the local knowledge. The dust interview provides contextual and insightful descriptions for the door-to-door survey results. This can be seen in the migration of pollution into homes, children playing on industrial sites, odours, and deposition of pollution.

The local knowledge of pollution in each community complements the findings of the soil and dust study (Lambert and Lane, 2004). Lead, arsenic and PAHs, were above Canadian soil quality guidelines, lead and arsenic were found to be moving into the homes, and there was no evidence to suggest the communities were different. Similarly, in the door-to-door survey, for the most part, there was no evidence to suggest local observations and experience was different in the three communities. In the dust interview, the residents in all three communities provided vivid and similar observations of the industrial pollution. The local knowledge and soil and dust study are supported by the historical scientific knowledge. In the late 1950s and early 1960s it was observed that Whitney Pier, Ashby and North End were experiencing significant dustfall from the slips occurring in the steel facility. Katz and McKay (1959) observed:

> When a slip or fall of the charge occurs in a blast furnace, the resultant, sudden increases in gas pressure forces open the two, sixty-foot diameter, safety valves at the top of the furnace. An immense reddish cloud of dust then escapes and rises high into the air. The dust cloud may reach a height of about 500 to 1500 feet within a matter of seconds as it mushrooms out rapidly. It then travels in the prevailing wind direction downwind until thoroughly dispersed by atmospheric turbulence. In the meantime, particles of dust settle out and reach ground level at various points of distances from the source (Katz and McKay, 1959, pp. 11).

The mushroom metaphor used by Katz was also invoked by one resident in North End:

> I noticed when I left the area the air was so much better elsewhere; when I reached Kelly's Mountain [outside of Sydney], I could see Sydney was an orange mushroom (SW-24-NE).

Fig. 2 was provided by one respondent and shows the orange cloud over Sydney.

Katz and McKay (1959) dust fall studies indicated that the predominant area of impact was north of the steel plant, or northeast part of Whitney Pier. Ironically, this area is different than the NOCO area, which is the only area considered to be adversely affected. A similar dustfall per month was observed in a circle about the industrial site that included North End and Ashby, and the remainder of Whitney Pier. North End had relatively smaller area affected by dustfall in 1959 than 1958. This might reflect the split response between light and heavy deposition in North End, in comparison to Whitney Pier and Ashby which indicated heavy deposition (Table 3). However, the survey results may also reflect the limited scale provided to capture ash deposition in the door-to-door survey; for example, only three response categories were provided and perhaps a continuous scale from 1 to 10 may have provided better resolution. Katz stated: "The dustfall or fall-out may create a nuisance by deposition and by discolouration of buildings, walls, textiles, laundry and other exposed surfaces" (Katz and McKay, 1959, p. 13). Consistent with this observation, residents in all three communities remarked that their homes, and laundry were affected by the emissions (Table 8). The Government of Canada, Havlock (1973) and Choquette (1974) undertook air dispersion modeling of the emissions from the industrial facility. Choquette

Table 9
Observation of odours in the dust survey

Community	Identifier	Observation
Whitney Pier	SW-8	Coke ovens; sulphur tar smell, rotten eggs — combination of all of these.
	SW-9	Sometimes get bad smells; sulphur smell, some other kind of smell — like alcohol from the steam tank.
	SW-10	Bad odours bleeding battery, hydrogen sulfide, rotten egg smell; various other smells; PCB fire smelled terrible — house was full of smoke; Get the smell of carbon from the billet mill steel plant.
	SW-12	Stinky — like melting smell of plastic; the overpass used to smell really bad.
	SW-15	Whenever tapping; depending on wind; sulphur smells, smell daily; gross smell, like sulphur smell, especially at the over pass; get on clothes; even when windows closed it would get in. Could even smell city dump whenever they were burning.
	SW-28	Can't describe the smell; smelled like work for the people.
	SW-29	Yes odours in the house when the plant was running, rotten egg like smell.
	SW-30	Yes, sulphur smelling.
	SW-31	Yes, smelled like rotten eggs.
	SW-39	Smell the coke oven; smelt the burnt coke, the tar under the overpass; coke ovens — smell sulphur–rotten eggs.
	SW-40	Stunk really bad like rotten eggs.
	SW-45	Yes, smelled the steel plant I knew I was home.
Ashby	SW-4	Yes, when first moved here, it took a long time to get used to it.
	SW-5	Smelled like rotten eggs; smelled in home periodically.
	SW-6	Can't describe smells, like rotten eggs.
	SW-7	Terrible smells, like sulphur; rotten eggs; every time they bleed the battery, orange smoke and odours.
	SW-19	Noticed when the strike was on that the air was much cleaner, and found it hard to breathe.
	SW-20	Yes, yellow smoke and it stank; rotten eggs, and all sorts of rotten, like sulphur I guess, worse than matches.
	SW-21	Like sulphur smell, rotten egg smell, sometimes like the tar pond.
	SW-28	Smelled like coal burning, chemical smell, rotten eggs.
	SW-42	Clothes always smelled — mother used to ask if we were smoking.
North End	SW-13	Yes it was foul — in the northend; especially in summer at night.
	SW-22	Tar ponds still smell; "pier fume" — no smell like it — tar sulphur/industrial chemical smell; daily the quenching smoke — this smelled.
	SW-24	Yes, smelled like rotten eggs, sometimes could not go outside.
	SW-26	Miserable odours; like burning coal; didn't notice odours because you get used to it; smelled them dumping slag; smelled rotten egg smell at times; on the tracks by the site, immediately get heart burn, and belch the taste out for a week or more.
	SW-32	Rotten eggs, whenever the prevailing wind blew this way.
	SW-33	From the tar ponds notice an odour, can't explain the odour — very gross; not like sewer like it does now. Got used to the smell but sometimes could not go outside.
	SW-34	Rotten eggs, sulphur, tar smell; when the wind is blowing this way sewage smell of the tar pond; odours come up from the basement.
	SW-35	Yes, always odour; rotten eggs, heavy smoky smell; Pretty well all the time.
	SW-36	Yes, smell coke ovens, smelled like rotten eggs.
	SW-37	There's nothing like it.
	SW-41	Yes; needed to close the windows, plus odours from the tar pond; even still the tar ponds stink and you need to keep the windows closed sometimes; smelled a lot like sulphur; rotten egg, and could taste it in your mouth. The water would come up under the basement, and notice the odour. The odour in the basement is very similar to the smell.

concluded that: "SYSCO's coke-making facilities appear to contribute heavily to air pollution levels in residential areas located south of the plant and significant reductions, at least in particulate emissions will be necessary to insure acceptable levels in ambient air quality" (Choquette, 1974, pp. i).

The limited PAH monitoring did not find large differences between Whitney Pier and Ashby (Atwell et al., 1984). The air dispersion results and PAH monitoring are consistent with the local knowledge, and inference that all three communities were affected.

Many residents noted the quenching process released smoke into the community (Table 8). Choquette (1974) provides a technical interpretation of the emission during quenching and potential exposure in the communities:

> Two kinds of emissions accompany quenching of coke. Fine coke particles or 'coke breeze', formed during the push and settling in the quench car, are raised into the plume of quenching steam by the draft from steam formation. More breeze is formed as water is flash-evaporated within the coke itself. Accordingly, the rising column of white vapor contains dust or grit of sizes ranging from 1 mm

Fig. 2. A picture of the orange mushroom cloud in Sydney (provided by one respondent).

on down to micrometer sizes which may be carried aloft to become a potential air pollution problem (Choquette, 1974, pp. 4).

Of significant interest to risk assessment, respondent SW-44 provided an account of the children's game of hide and seek in the quencher smoke (Table 8). Many residents provided knowledge of the grit affecting their homes.

In both surveys, the predominant odour was rotten eggs (Tables 4, 7 and 9), and this odour was frequently observed indoors (Table 5). There was no monitoring of hydrogen sulfide (H_2S) in Sydney and there has also been no evaluation or discussion of potential health effects related to H_2S. Choquette (1974) says that coking releases H_2S, coke dust, volatiles, SO_2, and that the H_2S content of coke oven gas from the Sydney operations was estimated at 3.5 grain S/scf of coke oven gas. The local knowledge provides insight into the exposure of the residents to H_2S among other emissions in the community and homes, which otherwise, has not been accounted for (Table 9).

Interestingly, only residents in Whitney Pier described a smell like mothballs and they also more frequently reported solvent-like odours (Table 4). Directly adjacent and south of Whitney Pier, northeast of the coke ovens site, a Domtar facility operated where the tar from the coke ovens was made into other chemical products like naphthalene, benzene and creosote. Residents in Whitney Pier remarked that the overpass that crossed over the Domtar facility was particularly odourous (SW-12, SW-15, SW-39).

In response to the question on the time frequency of the emissions, many respondents in the dust interview deconstructed the question and commented that the presence of the pollution was dependent on wind direction (Tables 7 and 8). The respondent's perception of wind direction as a key variable is consistent with technical approaches to model and explain dispersion of emissions. Atwell et al. (1984) in conducting PAH monitoring on the north and south sides of the coke ovens site in Whitney Pier and Ashby remarked:

> the plant can be considered as a ground level source with no effective plume rise, and emissions can be considered to be from a line source approximately 300 m in length. Because of this and the close proximity of the County Jail site (Ashby), and the Fredrick street site (Whitney Pier) (750 and 450 m away) to the coke ovens, it can be said that no one wind direction is responsible for transporting emissions from the coke ovens to the sampling sites (Atwell et al., 1984, pp. 23).

Other sources of potential contamination are the contributions from industrial, commercial, and residential fuel combustion, and railway, vessel, and motor vehicles. With respect to dustfall, Katz and McKay stated in their report: "it is apparent from an inspection of the data that the strong influence of Dosco operations, blankets out effectively whatever seasonal variation might be expected, if all sampling stations are included in the analysis" (Katz and McKay, 1959, p. 18). Similar findings were reported for dust deposition in other sampling periods (Katz et al., 1965; Kilotat and Wilson, 1970). For smoke and haze, Katz et. al. (1965) reported that the coke and steel facilities were the major sources but strong secondary sources were apparent during the heating season following the expected daily variations. Higher levels were observed on the cold winter mornings and lower readings in the warmer afternoons. Most respondents did not indicate a seasonal variation and the few that did suggested summer was worse (Table 7). Perhaps residents stayed indoors during the winter, and thus they did not experience the seasonal variations in smoke and haze. In the door-to-door survey no respondents reported burning coal for residential heat (data not shown). It is not known exactly when, but between 1960 and now, all homes had been converted from coal-fired heating.

The experience of the residents allows for a contextual understanding of the cumulative exposure to the industrial emissions in all three communities which is relevant for understanding potential health effects in the community. This is central critique of risk assessment in the environmental justice literature (Corburn, 2002a; Kuehn, 1996; Wing, 2005). The local knowledge provides insight into exposures which would not necessarily be captured by standard risk assessment procedures (Tables 5, 8 and 9). In addition, children played on the industrial sites perhaps resulting in more acute exposure than in the community (Table 6).

The residents were exposed to a complex mixture of sulphur compounds, including hydrogen sulfide, organics, PAHs, heavy metals, fine and coarse particulate matter. The exposure of the community to the industrial emissions raises the question of potential health effects. In particular with respect to the current Sydney environment, children are the 'unwitting target of environmental injustices' (Powell and Stewart, 2001), and are at increased risk from the complex mixture of contaminants in soil and dust (Lambert and Lane, 2004).

The health research in Sydney has found an increase in cancer incidence (Guernsey et al., 2000), cancer mortality (Health Canada, 1999, Band et al., 2003) and congenital anomalies (Dodds and Seviour, 2001) with respect to Nova Scotia and Canada. Whitney Pier and Ashby have been shown to have higher cancer mortality than the rest of Sydney (Band et al., 2003). The health research has not specifically evaluated the role of contamination but suggests that it is an important contributor. The vivid descriptions of the industrial pollution in the communities, supports the inference that the environmental contaminants released have played a role in adversely affecting health.

Based on the results of our surveys, we conclude that local knowledge developed in this paper is consistent with the physical studies, and provides a strong contextual basis for suggesting the communities living in the vicinity of the tar ponds have been adversely impacted by the industrial emissions. At this time, the residential communities have not been considered adversely impacted, except for Whitney Pier 'NOCO'. Considering the principle of justice (Lambert et al., 2003), the local knowledge and physical data suggest the three communities should be equally considered for remediation as part of the tar pond remediation policy.

5. Conclusion

The local knowledge developed in this paper is consistent with the physical studies. The local knowledge provides a strong contextual basis for inferring the dispersion modeling, dust-fall studies, soil quality studies do indicate that the communities living in the vicinity of the tar ponds have been adversely impacted by the industrial emissions. The residential communities have not been considered adversely impacted by the regulatory authorities. From a justice perspective, the collective results of the research suggest the three communities should be equally considered for remediation as part of the tar pond remediation policy, rather than the current policy of including a few streets and houses.

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