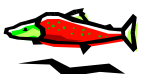
Exposure Pathway Assessment Worksheet for Dumpsite Wastes

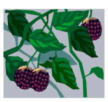
Town/home ⇐ How does it get there? ⇐ Dumpsite

Pathway end

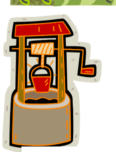

people


animals

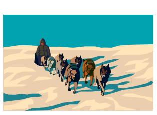

fish


plants

birds




Water we **drink** or use – treated or untreated.


pets

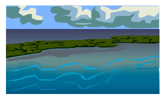

Places in or near homes that we contact, breathe from, or eat from


Areas where children play – (high hand-to-mouth risk)

Settles, flows, carries to:

Transport mechanism


Wind blowing in correct direction


Subsurface flow to river, lake, ocean, spring

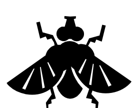

Overland flow from breakup, flooding, dump


Exposed dump visitors

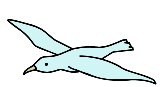

Contaminated vehicles back to town


rodents


foxes


Flies, other bugs

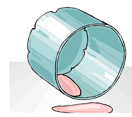

Mosquitoes, other biters


birds

Picked up, flows to, blows to, breathed by, adsorbed by

Fate of the contaminant

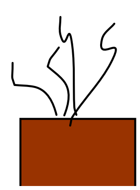

Burning to air- additional chemicals


Liquid waste seeping

Vapors to air


Wastes on ground


Leachate forms - additional


Gases from decomposition – additional chemicals

Formed by, decomposes or disintegrates into, escapes by, contained in:

Exposure to humans and animals <u>happens by:</u>

1. Breathing it,
2. Touching it,
3. Eating it, or
4. Absorbing it


Chemical

OR


Bacteria, virus

The exposure pathway worksheet uses basic epidemiology and eco-toxicology principles to identify exact "pathways" in which your community may be affected by contaminants and pathogens in wastes. Identifying these pathways can be helpful in developing proposals, writing workplans and outcomes, and planning how to address community health risks. You can use a pencil and connect the pictures, moving across from right to left (or it may be easier to work backwards). The worksheet is meant to help you with remembering all the different ways people are exposed and make it quicker to conduct your environmental planning. It can also be used with school education.

INSTRUCTIONS:

1. **Start in column 3 or 4** with the contaminant or pathogen you are concerned about. Some contaminants do not appear until after the wastes have been transformed. For these start in column 3. For example, dioxins are not in garbage, but are created when garbage is burned.

2. **Select a column 3 starting path.** Most of these paths will be at your dumpsite. Leachate always forms, smoke always forms if you burn, wastes are always present on the ground, there are always some vapors. But your contaminant or pathogen may not go through this path. For example, styrene from stryofoam is not released by stepping on the waste, and it is not released as a vapor. It is only released when the styrofoam is burned. The "fate" of a contaminant means how it ends up when it is released. There is a lot of chemistry involved, but at the basic level, it is whether it goes to air, water, ground, and in what form.

3. **Find a transportation method back to the village or subsistence area in column 2.** Remember the transport must take it back to a place that can connect the contaminant to your people. So if the wind blows away from town then it won't end up in a complete pathway. If the water flows into a river that is downstream of any drinking water and people do not fish from there, then there is no complete pathway. There is additional chemistry involved here that you can research if you like. Chemicals have different likelihood to move through air, ground, and water. For example, metals and PCB's do not move well through the ground – they get bound to most soils. So the further away your town is, the less likely that a metal like lead will move through the ground all the way to town. But you can still make the connection and complete a pathway – it is just a smaller risk. We will look at risk in the next part. Note, birds, rodents, mosquitoes and flies all have been found to not range much over 2 miles from their home base. So if your town if farther away from the dump, and you do not notice this problem, it is unlikely this is a transport mechanism.

4. **Connect the path to column 1.** Column 1 has direct exposure to humans and indirect – for example through eating fish that may have absorbed contaminated water. If the contaminant is transported to fish, then remember to complete the pathway, and draw the line up to humans.

5. **Repeat** for other possible pathways.

6. **Write out your pathways**. You can have this list later to insert directly into a proposal, workplan, or presentation about risks.

For example:

Some of the lead in dumped vehicle batteries is released into the air when the dumpsite is burned. The wind blows the emissions towards town, where residents are exposed to the lead by breathing it, as we can smell the smoke in town. The same pathway results in some exposure to lead to children who play in areas where the smoke settles. Because children are known to eat get small amounts of dirt in their mouth when playing, children are being exposed to the lead by ingestion of contaminated soil.

So 1. Vehicle battery lead to smoke to wind to breathing it, and
2. Battery lead to smoke to wind to settling in town to accidental ingestion

Another example:

Used oil, which contains benzene, toluene, xylene and other hazardous products leaks onto the ground from machinery and bottles and is transported by overland flow during flooding into our river upstream of our water intake. When the water is pumped, some of the oil and its contaminants are piped into our drinking water. It also seeps into the ground, where its contaminants are released and flow with the groundwater into a lake where we eat the fish from. We know the groundwater flows into this lake because it is downhill from the dumpsite.

1. Used oil – ground – overland flow-water system- drinking and contacting it, and
2. Used oil contaminants-ground-subsurface flow-lake-fish-eating it.

Breaking the Connection

When you have your pathway written down in the short form, you can use it to justify what your planned action will be. Exposure is all about whether a contaminant can be connected to a person. So to stop exposure, you must break the connection somewhere along the pathway. The best place to break the connection is what will work best for your community.

Example: (Note that the diagonal lines show where you can break the connection)

1. Vehicle battery lead to smoke to wind to breathing it MEANS getting rid of all batteries at the dump

2. Vehicle battery lead to smoke to wind to breathing it MEANS not burning (if that is possible)

3. Vehicle battery lead to smoke to wind to breathing it MEANS burning only when the wind doesn't carry emissions to town (if that is possible in your situation)

4. You can't cross out "breathing it" because people have to breathe. Although some Villages burn at night, which limits the amount of smoke people breathe, as they are more likely indoors.

Output and Outcome example: An output here might be X batteries removed from dump, or reduced smoke exposure to X people. An outcome example would be improved community health via eliminating a primary lead exposure pathway.

Qualitative Risk Assessment

There are many types of risk assessment. But they all evaluate in some way the risk associated with an activity. To get the absolute quantitative exposure risk associated with a contaminant at the dumpsite would take a lot of research and sampling, and then using the numbers in a math model. But qualitative risk assessments are also useful. They can be particularly effective when it is community risk and the community agrees on which factors are the greatest priority. Then as a trained environmental professional you can carry out the assessment.

The toxic risk of a contaminant is based on these things: how toxic the contaminant is and how much of the contaminant the person is exposed to. How much a person was exposed to depends on how often they are exposed, and much they get each time. How much they get each time will depend partly on your pathways. The longer it takes to get to a person – in distance and time, the less they get. That is because some of the contaminant disperses along the way. Some helpful sites for evaluating the risk of a contaminant as well as how likely it is to travel through air, water, or soil are given in www.nunat.net Go to contaminants. We like ATSDR toxfaqs http://www.atsdr.cdc.gov/toxfaq.html and Scorecard (www.scorecard.org).

When looking at a community, health practitioners also place a high priority on the total potential impact – the number of people that are being exposed, and the number of those people who might be more sensitive – such as children, elderly, and sick persons.

Assessment Example: So you will likely want to include the above factors in your community risk assessment. Otherwise, if this assessment is part of a workplan or proposal, it might be questioned as to why these factors are not included. Here is an example of how you can structure your risk assessment:

Raven Tribal Risk Assessment (Parameters ranked 1-3)

Exposure pathway	Relative contaminant toxicity	Portion of people exposed	Portion of sensitive population exposed	How often exposed	How much do you get		Relative Risk (Higher number denotes higher risk)
					How direct is pathway (1 is least direct)	How long (distance & time) is pathway (1 is longest)	
Lead in smoke	2	3	3	3	3	2	16

Instructions: For each column, assign a number 1-3 (low, medium, high), or 1-5 if you like. Then add the numbers. The pathway with the highest number presents the highest relative risk to the best of your information.

Do words make more sense to you than numbers? You can also assign a written statement in each column. For example, if you are looking at risk from inhaling contaminants in smoke, you could write "children are most affected because the school is nearest the dump" in the sensitive population column. Fill in each column. Some columns might say "unknown". Then consider how column contributes to the total risk, and evaluate with your best judgment. Then you can assign a high, medium, or low to the last column. At the end, you will still have a justification and a table that shows how you made your decisions and why. Remember you can work on this with other people, and ask their judgments or where you might find more information. Agency or non-profit staff scientists and public health professionals may have good information.

Have you heard?: Also, there is more known about some pathways than others. You may find or hear information from reliable sources that a certain exposure pathway is very high risk. You can use this information to make sure that this risk is high in your assessment. You do not need to spend much time in evaluating it, just cite the source of the information and then look at your other risks.

VALUES: A big advantage in qualitative risk assessments is that you may **include community values and other considerations** when deciding your risk. Here are some additional columns you could include and assign a number or statement to: effect on subsistence activities, Elder concern, effect on cultural values, effect on future economic development, e.g. These can all be aspects of risk to your community. The chemical might not affect health directly, but the contamination might affect quality of life in another way – through mental stress, loss of nearby subsistence, etc. that can translate to effects on health and well-being down the line.

Table 8
Emissions from burning pools of liquid fuels (mg/kg burned)

Class	Compound	Fuel oil	Crude oil
VOCs	Benzene	1022	251
	Toluene	42	
	Ethylbenzene	10	
	Xylenes	25	
	Nonane	13	
	Ethyltoluenes[a]	22	
	1,2,4-Trimethylbenzene[a]	32	
Carbonyls	Formaldehyde	303	139
	Acetaldehyde	63	32
	Acrolein	39	11
	Acetone[a]	35	20
	Propionaldehyde		
	Crotonaldehyde[a]	6	
	Methylethylketone	13	7
	Benzaldehyde[a]	104	44
	Isovaleraldehyde[a]	17	5
	Valeraldehyde[a]		
	p-Tolualdehyde[a]		13
	Methylisobutylketone	11	
	Hexanal[a]		
	2,5-Dimethylbenzaldehyde[a]	13	
PAHs	Naphthalene	162	44
	Acenaphthylene	99	4
	Acenaphthene	10	
	Fluorene	1	0.5
	1-Methylfluorene	26	0.2
	Phenanthrene	13	6
	Anthracene	15	1
	Fluoranthene	20	4
	Pyrene	2	5
	Benzo[*a*,*b*]fluorine	4	0.3
	Benzo[*a*]anthracene	5	1
	Chrysene	9	1
	Benzo[*b*&*k*]fluoranthene	7	2
	Benzo[*a*]pyrene	5	1
	Indeno[1,2,3-*cd*]pyrene	5	1
	Benzo[*g*,*h*,*i*]perylene		
PCDDs/Fs	TCDD		
	PeCDD		
	HxCDD		
	HpCDD		7.07×10^{-5}
	OCDD		1.34×10^{-4}
	TCDF		2.05×10^{-4}
	PeCDF		
	HxCDF		1.86×10^{-5}
	HpCDF		
	OCDF		
	Total PCDD/F		4.28×10^{-4}

Source. Based on pollutant concentrations from Ref. [69] and PM and CO emission factors from Ref. [25].
[a] Compound of interest not on HAP list.

characterize the PCDD/F emission factor from barrel burning [36,37]. The variation between duplicate runs of the later tests was significantly less than in the original ones. Based on these more recent studies, this source has been moved to the quantitative inventory of dioxin sources in the US [1]. Based on estimated AFs, barrel burning appears to be one of the largest measured sources of PCDD/F in the US now that maximum achievable control technology standards have been implemented for all of the major industrial PCDD/F sources (it must be noted that other non-characterized sources could be as significant as barrel burning, but no data are available). Table 9 lists the emissions for air toxics from open burning of household waste in barrels. To derive the emissions estimates in Table 10, the data for the four experimental conditions [34], were averaged, with non-detects set to zero. When compound-specific analyses were performed (e.g. PAHs, chlorobenzenes, and carbonyls), the data from the compound-specific analysis was used instead of the general screening analysis. PCDD/F and PCB data were taken from Ref. [37], and represent the average of baseline conditions reported in their experiments.

3.3.2. Landfill fires and burning dumps

For many of the same reasons that open burning of household waste in barrels is a major source of PCDDs/Fs, it is speculated that burning dumps and landfill fires might be similarly high emitters of PCDDs/Fs and other air toxics. There are currently very little data available on emissions of air toxics from these types of open burning. There were a few studies published that had data available on air toxics from research in Scandinavia. Ruokojarvi et al. [75] presented data from both intentional and spontaneous fires at municipal landfills in Finland. Ettala et al. [76] discussed occurrences and circumstances of landfill fires, also in Finland; little quantitative data were presented in this study, however. There was a study by Pettersson et al. [77] that reported on emissions of criteria pollutants from both actual and simulated fires in Sweden. Table 10 lists the emissions of air toxics from burning dumps and landfill fires. Note that data were not sufficient to convert the information to emission factor units, so only plume concentrations are reported in Table 10. In light of the lack of emission factors, a qualitative comparison was performed between landfill fires and open burning of household waste in barrels. Comparing the relative emissions of individual PAHs and PCBs to Table 9 (backyard barrel burning), the total PCBs were somewhat higher than individual PAHs in the case of the landfill fires, but an order of magnitude or so less than individual PAHs in the case of the open burning of household waste in barrels, which suggests that different combustion conditions may dominate in a landfill fire than are predominant in a backyard burning situation and that it is not appropriate to extrapolate emissions from that source to this source.

3.3.3. Tire fires

Approximately 240 million scrap rubber tires are discarded annually in the US [78,79]. Viable methods for reclamation exist. Some of the attractive options for use of scrap tires include controlled burning, either alone or with another fuel such as coal, in a variety of energy intensive

Table 9
Emissions from barrel burning of household waste (mg/kg material burned)

Class	Compound	Emissions
VOCs (1)	1,3-Butadiene	141.25
	2-Butanone	38.75
	Benzene	979.75
	Chloromethane	163.25
	Ethylbenzene	181.75
	m,p-Xylene	21.75
	Methylenechloride	17.00
	o-Xylene	16.25
	Styrene	527.50
	Toluene	372.00
SVOCs (1)	2,4,6-Trichlorophenol	0.19
	2,4-Dichlorophenol[a]	0.24
	2,4-Dimethylphenol[a]	17.58
	2,6-Dichlorophenol[a]	0.04
	2-Chlorophenol[a]	0.95
	2-Methylnaphthalene[a]	8.53
	2-Cresol	24.59
	3- or 4-Cresol	44.18
	Acetophenone	4.69
	Benzylalcohol[a]	4.46
	Bis(2-ethylhexyl) phthalate	23.79
	Di-*n*-butylphthalate	3.45
	Dibenzofuran	3.64
	Isophorone	9.25
	Pentachloro nitrobenzene	0.01
	Phenol	112.66
Chlorobenzenes (1)	1,3-Dichlorobenzene	0.08
	1,4-Dichlorobenzene	0.03
	1,2-Dichlorobenzene[a]	0.16
	1,3,5-Trichlorobenzene[a]	0.01
	1,2,4-Trichlorobenzene	0.10
	1,2,3-Trichlorobenzene[a]	0.11
	1,2,3,5-Tetrachloro benzene[a]	0.03
	1,2,4,5-Tetrachloro benzene[a]	0.02
	1,2,3,4-Tetrachloro benzene[a]	0.08
	1,2,3,4,5-Pentachloro benzene[a]	0.08
	Hexachlorobenzene	0.04
PAHs (1)	Acenaphthene	0.64
	Acenaphthylene	7.34
	Anthracene	1.30
	Benzo[*a*]anthracene	1.51
	Benzo[*a*]pyrene	1.40
	Benzo[*b*]fluoranthene	1.86
	Benzo[*ghi*]perylene	1.30
	Benzo[*k*]fluoranthene	0.67
	Chrysene	1.80
	Dibenzo[*ah*]anthracene	0.27
	Fluoranthene	2.77
	Fluorine	2.99
	Indeno[1,2,3-*cd*]pyrene	1.27
	Naphthalene	11.36
	Phenanthrene	5.33
	Pyrene	3.18
Carbonyls (1)	Acetaldehyde	428.40
	Acetone[a]	253.75
	Acrolein	26.65
	Benzaldehyde	152.03
	Butyraldehyde[a]	1.80
	Crotonaldehyde[a]	33.53
	Formaldehyde	443.65
	Isovaleraldehyde[a]	10.20
	p-Tolualdehyde[a]	5.85
	Propionaldehyde	112.60
PCDDs/Fs and PCBs (2)	Total PCDDs/Fs	5.80×10^{-3}
	TEQ PCDDs/Fs	7.68×10^{-5}
	Total PCBs	1.26×10^{-1}
	TEQ PCBs	1.34×10^{-6}

Source. (1) Ref. [34]. (2) Ref. [37].
[a] Compound of interest not on HAP list.

processes, such as cement kilns and utility boilers [80–82]. Another potentially attractive option is the use of ground tire material as a supplement to asphalt paving materials. The Intermodal Surface Transportation Efficiency Act [83] mandates that up to 20% of all federally funded roads in the US include as much as 20 lb (9 kg) of rubber derived from scrap tires per ton (907 kg) of asphalt by 1997. Lutes et al. [84] measured the air emissions from adding tire rubber to asphalt. In spite of these efforts, less than 25% of the total amount of discarded tires are reused or reprocessed, and the remaining 175 million scrap tires are discarded in landfills, above-ground stockpiles, or illegal dumps. In addition,

Table 10
Emissions from burning dumps and landfill fires (ng/m^3)

Class	Compound	Controlled landfill fire	Uncontrolled landfill fire
PAHs	Acenaphthylene	90	60
	Acenaphthene	50	30
	Fluoranthene	100	50
	Phenanthrene	520	30
	Anthracene	160	85
	Fluorene	120	180
	Pyrene	120	170
	Benzo[*a*]anthracene	60	60
	Chrysene	80	70
	Benzo[*b&k*]fluoranthene	50	20
	Benzo[*a*]pyrene	20	15
	Indeno[1,2,3-*cd*]pyrene	10	10
	Dibenz[*a,h*]anthracene	10	10
	Benzo[*g,h,i*]perylene	10	10
	Total PAHs	1480	810
	Total PCBs	15.5	590

Source. Ref. [75].

TABLE 16.4-1

EMISSION FACTORS FOR OPEN BURNING OF MUNICIPAL REFUSE (EPA, 1997 AND EPA, 1995a)

Pollutant	Emissions (lb/ton entire refuse weight)	Emissions (lb/ton actually burned)	Emission Factor Source
Sulfur Oxides	1.0		AP-42 (EPA, 1995a)
Carbon Monoxide	85		AP-42 (EPA, 1995a)
Methane	13		AP-42 (EPA, 1995a)
Nitrogen Oxide	6		AP-42 (EPA, 1995a)
VOCs[a]		8.556	EPA, 1997
PM_{10}		38	EPA, 1997
$PM_{2.5}$		34.8	EPA, 1997
Chlorobenzenes		0.0008484	EPA, 1997
Benzene		2.48	EPA, 1997
Acetone		1.88	EPA, 1997
Styrene		1.48	EPA, 1997
Phenol		0.28	EPA, 1997
Dichlorobenzenes		0.00032	EPA, 1997
Trichlorobenzenes		0.00022	EPA, 1997
Tetrachlorobenzenes		0.000148	EPA, 1997
Pentachlorobenzene		0.000106	EPA, 1997
Hexachlorobenzene		0.000044	EPA, 1997
Total Polycyclic Aromatic Hydrocarbons (PAHs)[b]		0.132	EPA, 1997

Some Chemicals That Have Been Found In Leachate – Leachate is the liquid that forms when wastes decompose to the earth.

TYPICAL DOMESTIC REFUSE LEACHATE CONSTITUENT CONCENTRATIONS (ppm=Parts per million)

Iron 200 - 1,700
Zinc 1 - 135
Arsenic 0 - 70
Lead 0 - 14
Phosphate 5 - 130
Sulfate 25 - 500
Chloride 100 - 2,400
Sodium 100 - 3,800
Nitrogen (Kjeldahl) 20 - 500
Hardness (as CaCO3) 200 - 5,250
COD 0 - 750,000
BOD 9 - 55,000
TOC 5 - 30,000
TDS 0 - 51,000
TSS 2 - 140,000
Total Residue 1,000 - 45,000
Nickel 0.01 - 0.8
Copper 0.10 - 9.0
pH 4.00 - 8.5
*From *Characterization of MWC Ashes and Leachates from MSW Landfills, Monofills, and Co-Disposal Sites* (EPA, 1987f)

Chemicals monitored for in leachate if performance based design option is selected for large landfills. Upper allowed limit in ppm is given:(In Federal Register: 40 CFR 258.40; 56 FR 51022;October 9, 1991)

Arsenic 0.05
Barium 1.0
Benzene 0.005
Cadmium 0.01
Carbon tetrachloride 0.005
Chromium (hexavalent) 0.05
2,4-Dichlorophenoxy acetic acid 0.1
1,4-Dichlorobenzene 0.075
1,2-Dichloroethane 0.005
1,1-Dichloroethylene 0.007
Endrin 0.0002
Fluoride 4.0
Lindane 0.004
Lead 0.05
Mercury 0.002
Methoxychlor 0.1
Nitrate 10.0
Selenium 0.01
Silver 0.05
Toxaphene 0.005
1,1,1-Trichloroethane 0.2
Trichloroethylene 0.005
2,4,5-Trichlorophenoxy acetic acid 0.01
Vinyl Chloride 0.002

VOC's (volatile organic compounds) in Wisconsin landfill leachate: (Evaluation of Volatile Organic Compounds in Wisconsin Landfill Leachate and Lysimeter Samples By N. Klett, T. B. Edil, C. H. Benson)

chemical	% of landfills that had it
1,1,1-trichloroethane	89
1,1-dichloroethane	88
Acetone	60
Benzene	52
Chlorobenzene	75
Chloroethane	93
1,2-dichloroethylene	3
Dichloromethane	100
Ethylbenzene	62
Methyl ethyl ketone	50
Methyl tertiary butyl ether	100
Naphthalene	73
p-dichlorobenzene	76
Trichloroethylene	83
Tetrachloroethylene	100
Tetrahydrofuran	47
Toluene	56
Vinyl chloride	100
Xylene	67
Styrene	67
Carbon disulfide	100

In their review of landfill leachate studies throughout the u.s., it was found that Aromatic hydrocarbons, alkanes, and alkenes were detected in all of the studies that concentrations of the alkanes and alkenes typically fell between 0.1 and 1,000 µg/l, with the exception of dichloromethane, 1,1,1-trichloroethane, and 1,1,2-trichloroethane, which ranged between approximately 1.0 and 10,000 µg/l. Concentrationsof the aromatic hydrocarbons also ranged between 0.1 and 1000 µg/l, with the exception of toluene and benzene, which ranged between approximately 0.1 and 10,000 µg/l.

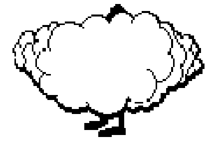
One common aspect is that the concentration of each VOC varies over a broad range.

Dust

www.zendergroup.org

1. **Lowering speed of vehicles** from 45 miles to 35 miles per hours on unpaved roads reduced Particulate Matter (PM – i.e. dust) by 22%

2. **How far does dust settle?** 1 mile of unpaved road with a vehicle going over 1 time per day for a year creates 1 ton of dust **500 ft out from the road**. (USFS study). *How far out does the dust go from Village roads?* What signs are there?



3. To estimate a contaminant **concentration in the air from an unpaved road**, use a dust loading factor of 8×10^{-6} kg/m^3 to obtain the concentration in air in g/m^3.

4. The current **dust emission factor for unpaved roads** is 2.0 lbs PM10/VMT (vehicle mile traveled).

5. **Dust emissions can be prevented or reduced** in just four basic ways:
   - ✓ Limiting the creation or presence of dust-sized particles. (e.g. reducing speeds, reducing PM sources or frequency of use)
   - ✓ Reducing wind speed at ground level. (e.g. barrier from 3 -5 ft along roads, reducing ATV speeds)
   - ✓ Binding dust particles together (dust adhesives for roads)
   - ✓ Capturing and removing dust from its sources. (e.g., better stoves, 4 stroke instead of 2)

6. **How are you breathing?** For PM larger than about PM3 - PM5, **how much and whether a particle is inhaled depends on breathing through nose or mouth**. Through the nose, less is ultimately inhaled into the airways and body. *More mouth breathing results in deeper lung penetration and more PM inhalation.*

7. **Asthma and Dust:** Exposure to motor traffic emissions can have a significant effect on respiratory function in children and adults. One study showed that children living within 100 meters of heavily traveled roadways have significantly higher rates of wheezing and diagnosed asthma. Among adults, a study of street cleaners in Copenhagen who were exposed to traffic-related air pollution found an odds ratio of 2.3 for asthma when the street cleaners were compared to a control group of cemetery workers in the same city.

8. **Global Dust effects:** Global dust is increasing all around the world. Circulation patterns are changing and getting stronger. As a result, dust from Asia is increasingly being swept up and deposited in Alaska in the Springtime. The air quality from this dust may not be noticeable then. But when the snow melts, that dust is added to what is already in the village. This dust has contaminants as well.

9. **Snowmelt Effects**: Not enough is known as to the amount of global dust to local village dust. But the global dust alone is enough to move up Breakup by 2 to 4 weeks. The dirtier the snow – meaning the more PM that is spread out on the snow, the faster the snow melts.

10. **Where do airborne contaminants settle?** You can visually assess where PM and its associated contaminants settle by using traditional knowledge and observation. Airborne particles flow with the air. When the airflow lessens, the larger particles begin to settle. At low or no wind speeds, the settleable particles will drift down. PM tends to get entrained in precipitation, including snowdrifts. A PM/Snowdrift study showed where the snowdrifts were highest, the highest total amount of PM and its associated contaminants was found – although the concentration in the snow was lower (more snow/water to dilute). Where in the village does dust settle the most? Those are the areas to have children avoid, move drying racks from, etc. OR determine what about that area is making the dust settle (are there tarps, connexes, old buildings that can be moved, or traffic redirected?).