

Indoor Air Technologies Inc

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## Soil gas - hazards and solutions

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- Radon monitor gives real time reading. Hourly variations require 4 days to obtain good picture of levels.

- Lower explosive limit (LEL: methane, pentane...) and hydrogen sulphide (H<sub>2</sub>S) monitor organic matter decay gases.

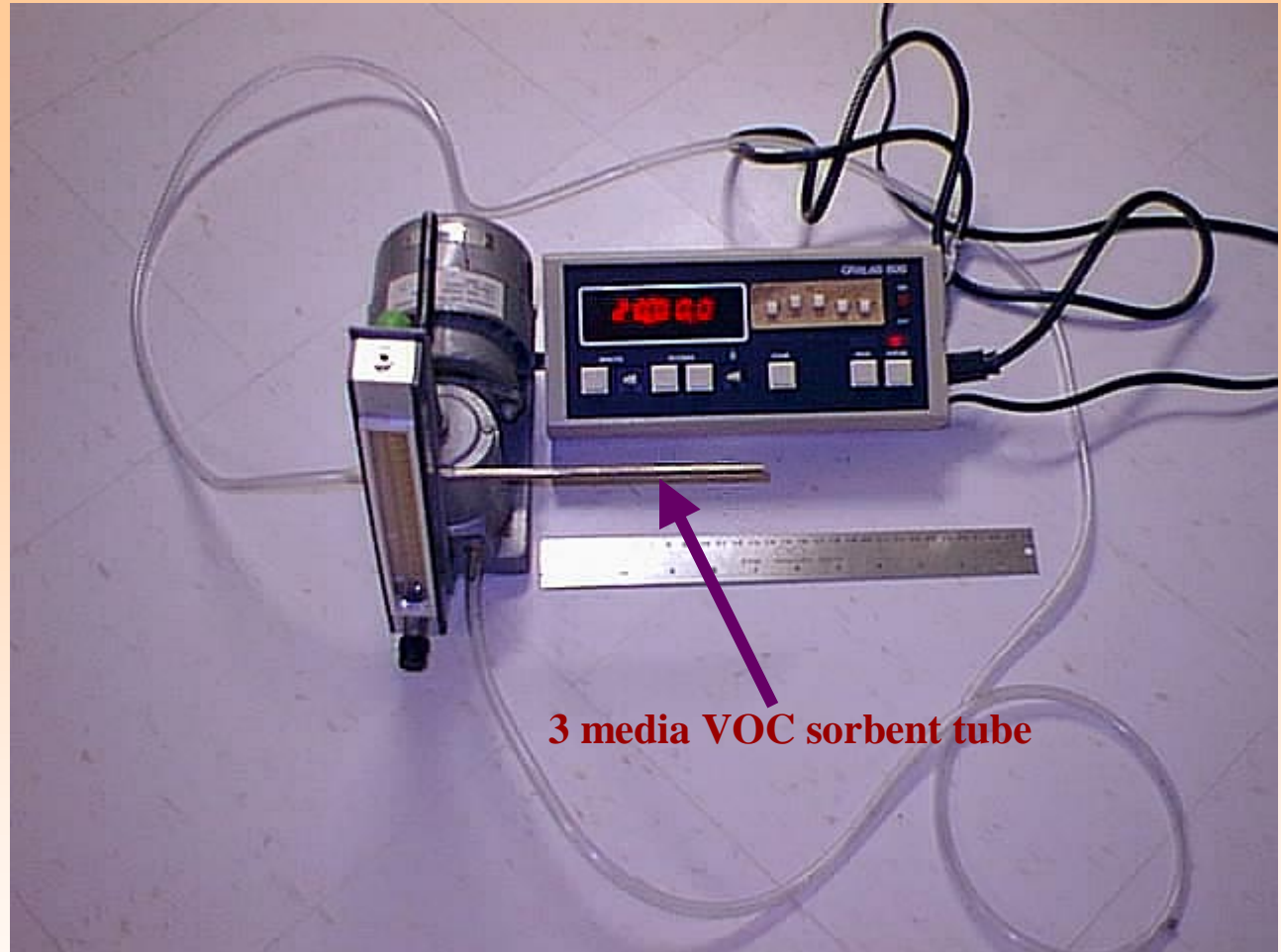


**Radon monitor**



**LEL, H<sub>2</sub>S monitor**

**VOC sampling identifies various soil gas problems including toxic waste offgasing and microbial offgasing.**



**Sampling pump with sorbent volatile organic compound sampling tube**

### **Smoke pencil**

Used to identify air flow directions and approximate velocities.

### **Micromanometer**

Used to measure pressure differences ( $\pm 0.1$  Pa) and air velocities.



Smoke pencil for identifying air currents



Micromanometer for measuring flows and pressure differences

## SOIL GASES

- methane
- hydrogen sulphide
- methylene chloride
- gasoline VOCs
- radon
- pesticide toxins, Cl, HCn...
- microbial VOCs, ketones, alcohols, esters, aromatics...

### **Methane**

Colorless, odorless, explosive. Produced by decaying vegetable matter. It is the main component of natural gas.

### **Hydrogen sulphide**

Colorless, very poisonous gas produced by decaying animal or vegetable matter.

### **Dichloromethane (methylene chloride)**

Chloroform-like odor. Solvent. Soil gas originating in garbage. Formed by the combination of methane and chlorine. The chlorine is leached from paper. Affects the CNS. Causes anoxia.

## SOIL GASES cont'd

### Gasoline

Sweet odor, explosive. Causes sensory irritation and affects the CNS.

### Radon

Colorless, odorless, radioactive, gas. Causes 5% of lung cancers. Exposure to 4 pCi/l equivalent to smoking 2 packs of cigarettes per day.

### Pesticides

Highly toxic.

e.g. chlordane  $C_{10}H_6Cl_8$

e.g. hydrogen cyanide (HCN) bitter almond smell - irritant, anoxia

e.g. phosgene ( $Cl_2CO$ ) smokers exposed to pesticides at risk - irritation, anoxia, pulmonary edema.

- methane
- hydrogen sulphide
- methylene chloride
- gasoline VOCs
- radon
- pesticide toxins, Cl, HCN...
- microbial VOCs, ketones, alcohols, esters, aromatics; toxic propagules



## SOIL GASES cont'd

- methane
  - hydrogen sulphide
  - gasoline
  - radon
  - pesticides
  - microbial
- microbial VOCs,  
ketones, alcohols,  
esters, aromatics;  
toxic propagules



### Mold

Microbial VOCs are produced during the growth of a wide range of bacteria and fungi, forming complex molecules of alcohol's, aldehydes, esters, hydrocarbons, and aromatics. Earthy odours are sometimes markers. MVOC effects include nausea, malaise, stuffiness and wheezing.

Microbial propagules (e.g. spores, NSI) from soil (e.g. crawl space; construction) can be toxigenic. e.g. *Penicillium auranteogrisium* (kidney disease), *Penicillium brevicompactum* (teratogenic, immunosuppressive), *Stachybotrys chartarum* (pulmonary haemorrhage in infants, lung disease in adults)

# Case History # 1

## Service station restaurant gasoline fumes

### Problem

Gasoline fumes were above LEL high alarm level in air entering a service station restaurant. Venting above a sump pit where levels were highest did not solve the problem.

### Solution

The sump pit was sealed tightly and then exhausted under pressure. This caused the under-ground fumes from a leaking tank to be drawn into weeping tile without entering the building.

Restaurant max  
LEL\* TVOC

**April 28**

Complaints of headache

65% 125 mg/m<sup>3</sup>

**June 2**

Blower installed to exhaust sump pit and weeping tile

14 mg/m<sup>3</sup>

**June 4**

3 mg/m<sup>3</sup>

\* Lower explosive limit, LEL (pentane equivalent)

low alarm 10%

high alarm 20%



## Case History # 2

### Basement petroleum fumes

#### **Problem**

Strong petroleum fumes were noticed in a bungalow basement. The fumes were entering via an interior block wall bracing the perimeter block wall.

#### **Solution**

The block wall was sealed and exhausted outdoors continuously by a blower for several months until the odor disappeared.

- A PID identified petroleum fumes on one of the basement foundation block walls, with highest readings (TVOC = 20 mg/m<sup>3</sup>) in an adjoining interior abutment block wall.
- Source possibilities included heating oil used in the furnace, possibly leaking from a line passing under the slab, and leaking gasoline from an underground tank at a nearby gas station up the hill from the house.
- GC/MS headspace analysis vs. basement air findings identified the source as gasoline using benzene as a marker.



## Case History # 2 cont'd

### Basement petroleum fumes

#### **Problem**

Strong petroleum fumes were noticed in a bungalow basement. The fumes were entering via an interior block wall bracing the perimeter block wall.

#### **Solution**

The block wall was sealed and exhausted outdoors continuously by a blower for several months until the odor disappeared.

- It was concluded that the fumes originated from gasoline discarded from a lawn mower a few weeks earlier in a depression in the lawn (TVOC = 30 mg/m<sup>3</sup> in the soil here using PID). This depression marked a break in an old underground water drain leading from the basement. House stack effect drew air up the pipe to the basement.



### Problem

Concern about mold exposure of a daughter whose bedroom was in a ranch-style back split/bungalow basement led to fungal investigation. It identified toxigenic species in the bedroom air. The source was a nearby crawl space with a soil floor.

### Solution

The crawl space was sealed and depressurized with a continuously operating blower exhausting to the outdoors.

## Case History # 3

### Basement bedroom toxic mold

#### Fungal aerosols March 11

	CFU/m <sup>3</sup>	Species in order of colonies
Basement bedroom	175	Penicillium auranteogrisium Penicilium brevicompactum penicillium sp. Cladosporium, NSI
Crawl space	TNTC	Penicillia, Aspergilli, Stachbotrys chartarum

# Case History # 4

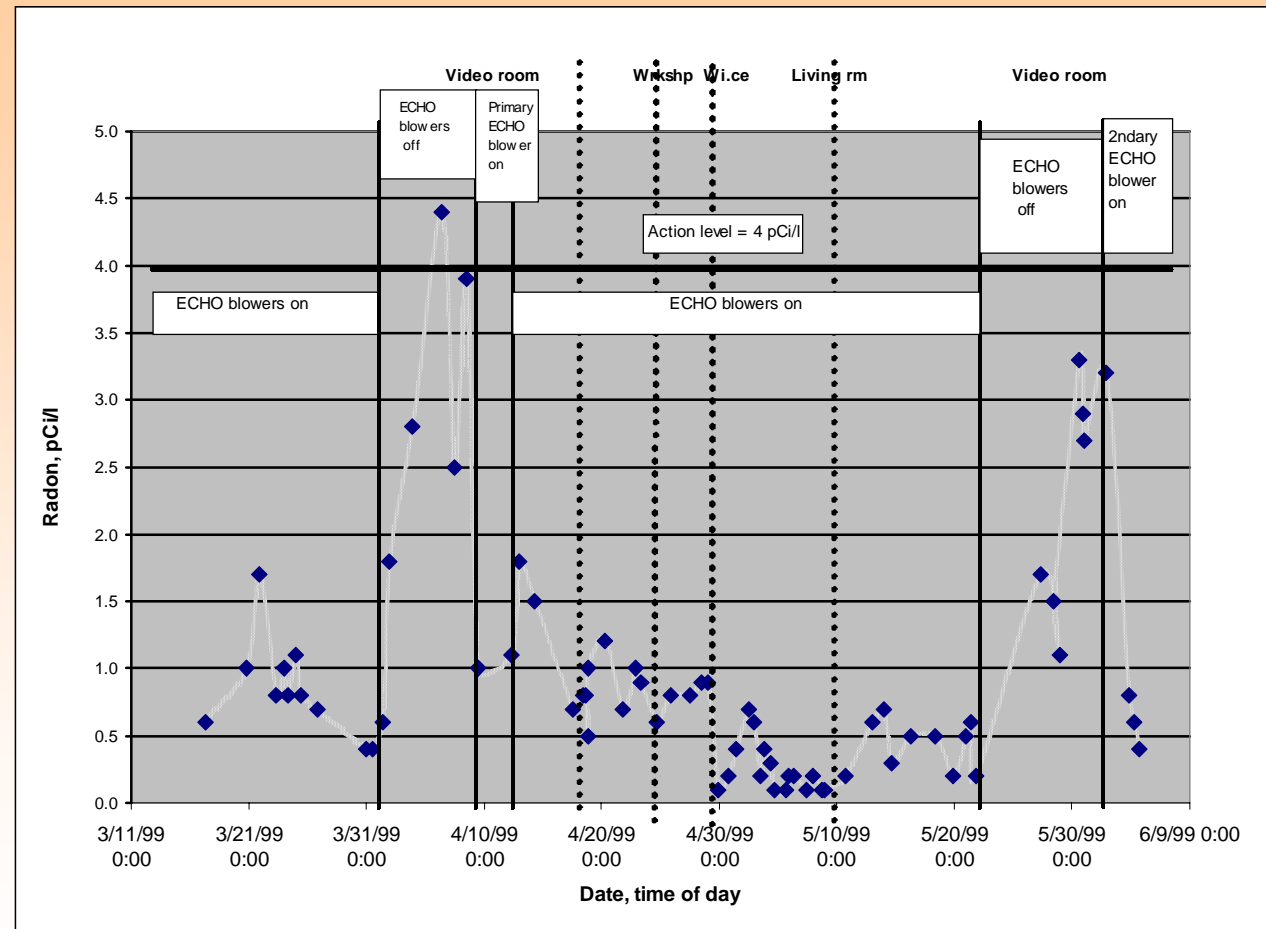
## Radon exposure

### Problem

Radon levels in an Ottawa Rockcliffe Park house basement exceeded 4 pCi/l. This exposure is equivalent to smoking 2 packs a day in terms of lung cancer risk.

### Solution

The basement was finished with the ECHO System. It forms a ventilated and depressurized continuous subfloor and perimeter stud wall barrier to radon and any other soil gas entry.



# Case History #6

## Store basement

### **Problem**

Sewer smell in basement

### **Solution**

- Sump sealed and exhausted continuously outdoors with 65 watt blower

**Staff and patrons complained of sewer smell in the basement of the store.**

**Recommended that sump be sealed and exhausted by a 110 CFM blower with a speed control.**

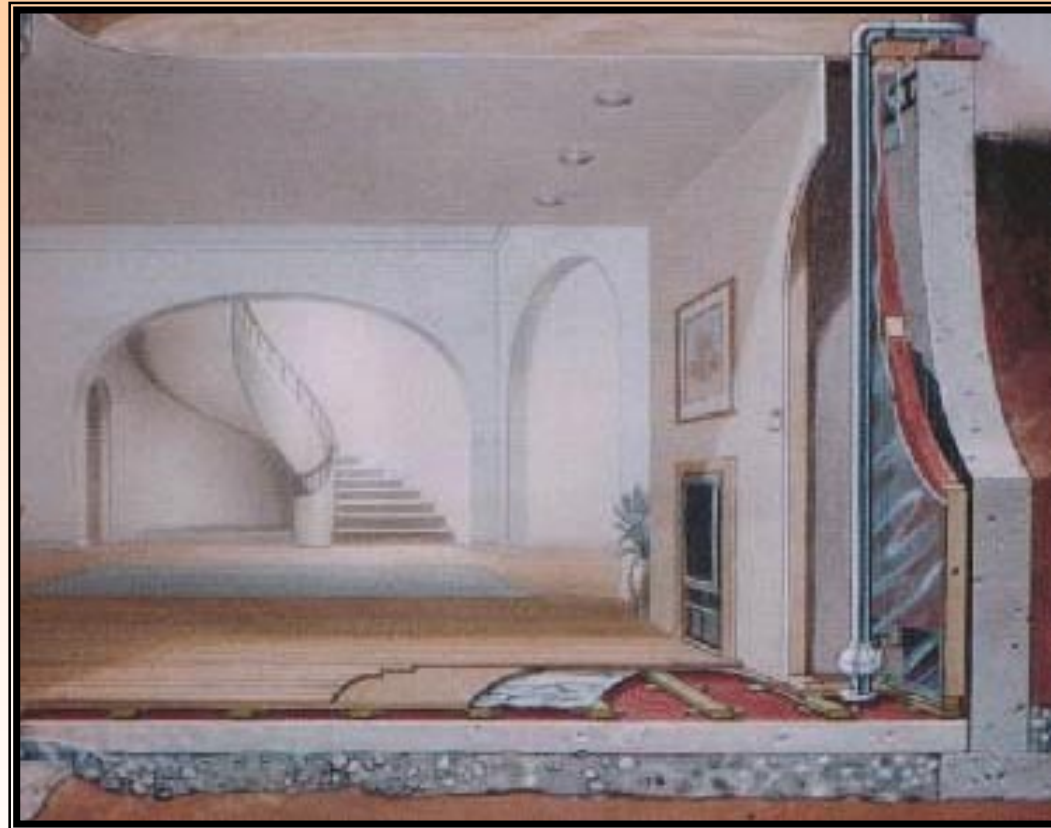
**At 0,5 Pa negative pressure, some sewer smell still observed in the basement.**

**Sump was better sealed, so depressurization above 2 Pa. Problem solved.**

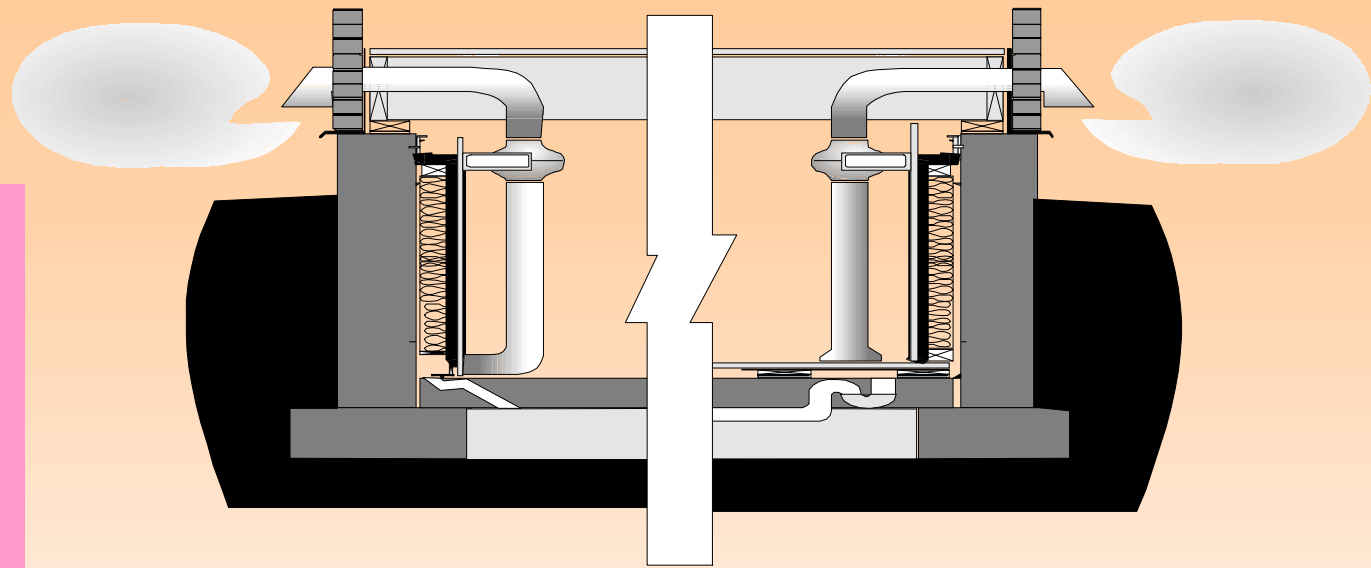
The ECHO System prevents soil and envelope gases and vapour entry by depressurization - not by air circulation.

It removes leakage water by drainage and evaporation.

## ECHO System basement finishing



Depressurized walls and sub-floors prevent finished basement soil gas entry



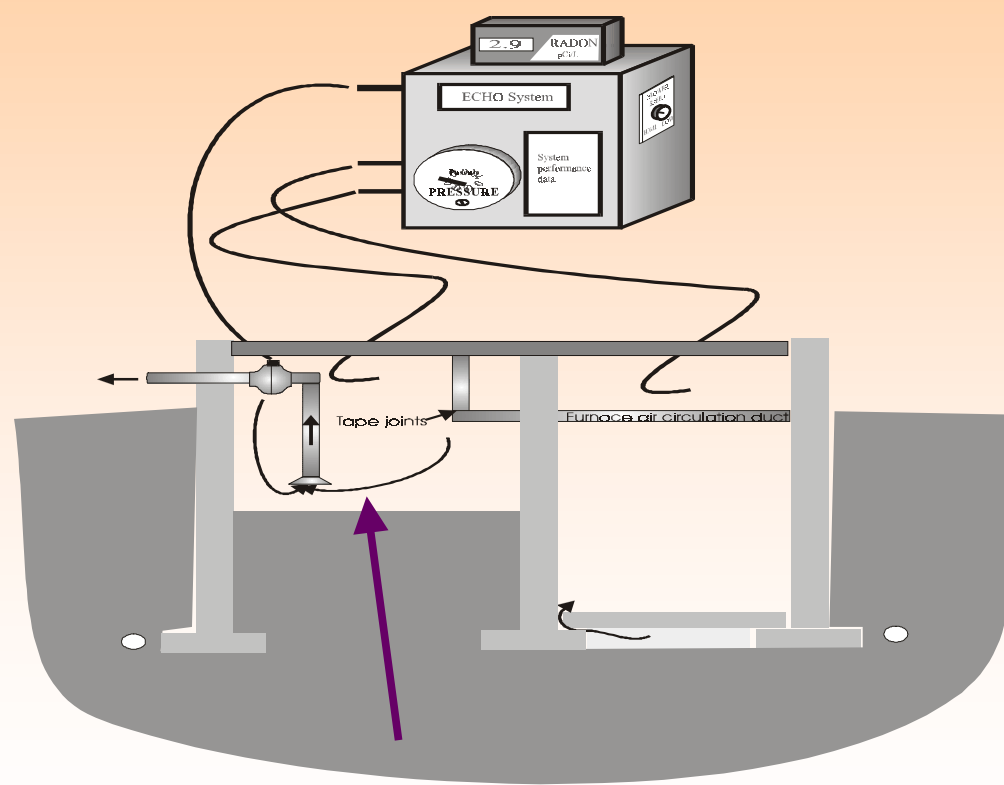
**Drained & depressurized wall & sub-slab**

**Drained & depressurized wall & Sub-floor**



Exhaust ventilation dehumidifies and warms the space with house air, while it depressurizes it.

Crawl spaces can be strong sources of mold emissions and soil gases into the living space.



**Crawl space exhaust**

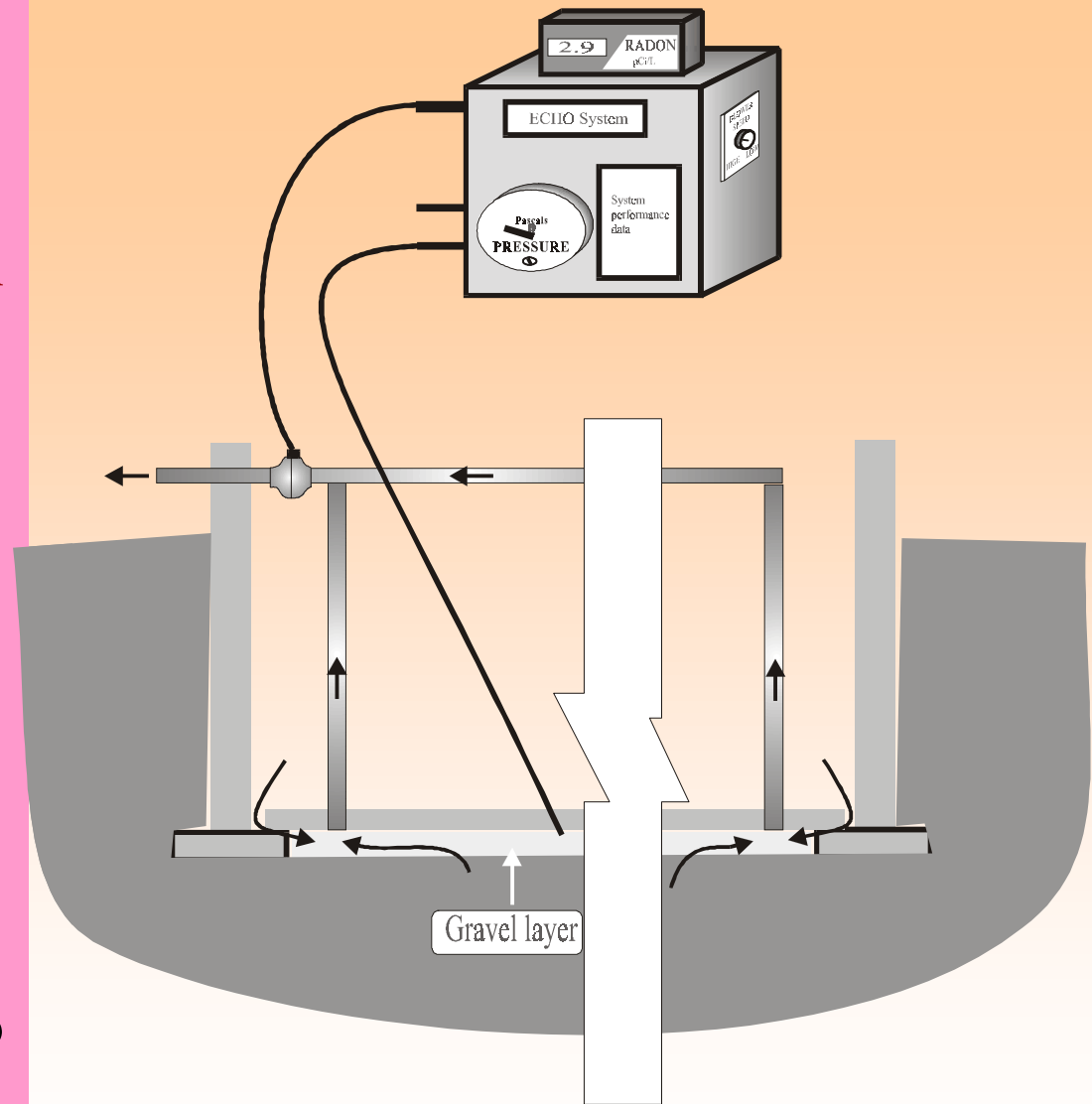
## Problem

Soil gas entry through the slab cracks and openings.

## One solution

### Sub-slab depressurization

- provided there is a gravel layer under slab
- the foundation underground has fairly air tight boundaries.
- SSD does not prevent soil gas entry through foundation wall cracks and cavities.
- Minimize exhaust rate to avoid foundation problems (frost heave, soil drying).



**Sub-slab depressurization**

# Soil Gas Hazards

## Summary

- Lung cancer - radon gas (concern in perhaps 1/5 houses, ? schools)
  - radon is present in all soil
  - radon levels cannot be predicted from site location alone
  - foundations on stone are high risk
- Toxic effects: irritant, CNS affects, allergenic effects, kidney disease, cancer, anoxia...
  - toxigenic molds e.g. *S. chartarum*, *P. auranteogrisum* in crawl spaces
  - pesticides used in control of insects, rodents e.g. Cl, HCn...
- CNS effects, explosions
  - underground gasoline leaks
  - waste disposal
  - natural gas leaks
  - contaminated fill
  - wet organic soil

# Soil Gas Solutions

## Summary

- Sump pits
  - seal and power vent outdoors, depressurizing weeping tile around perimeter of foundation
- Slab
  - seal and power vent sub-slab air outdoors
    - needs gravel under slab
    - 50-150 cfm exhaust rate
    - does not eliminate foundation wall entry
- Slab and foundation walls
  - use the ECHO System: seal sub-floors and perimeter stud walls against foundation and power vent cavity air outdoors
    - 10 - 100 cfm exhaust rate, depending on system tightness
    - coincidentally solves finished basement mold problem
    - coincidentally provides leakage protection
    - coincidentally provides filtered house ventilation air
- Crawl spaces
  - seal envelope and power vent outdoors
    - coincidentally dehumidifies crawl space