Infrasound and Low Frequency Noise: A Public Health Nightmare

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Glasgow, Scotland, Sept 22, 2017
Disclaimer

We:

- *Do not harbour anti-technology sentiments*;
- *Consider industrial activities to be important to modern technological societies*;
- *Have scrutinized data under one, and only one, agenda - pure scientific inquiry*;
- *Are not producing a report arguing against industrial complexes*. 
• Humans do not perceive x-rays.
• Excessive exposure to x-rays can be harmful.
• A chest x-ray, once a year, is not considered harmful.
Low frequency waves can propagate over larger distances than higher frequency waves.
Acoustic wave = Pressure wave (longitudinal wave)

An acoustic wave = “sound” if and only if humans can perceive it with the ear.

World Health Organization: Noise = Inanimate Mechanical Forces
The deciBel unit, dB, is used to measure the amplitude of the acoustic waves.

- **1920**
  - 23 healthy, young males
  - with good hearing (assumed)
  - exposed to series of different, single, pure tones at different levels of loudness via telephone earpieces - occluded ear
  - asked to score the sounds for equal loudness.

Fletcher–Munson Equal Loudness Curves
Human Hearing & Noise Protection

1932

1932

1932

1932
The dBA metric

Specifically designed (decades ago) to protect the human hearing function.
This team of scientists prefers dB Linear.

NO weighting network!

dBA - blue
dB B - yellow
dBC - red
dB D - black
Linear capture

Microphone frequency response curve, as used by this team.
dBA vs. dBLinear

**dBA LEVELS IN DIFFERENT ENVIRONMENTS**

- **Cockpit:** 72.1 dBA
- **Train:** 71.4 dBA
- **Car:** 71.2 dBA

<table>
<thead>
<tr>
<th>Environment</th>
<th>Amplitude (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cockpit</td>
<td>72.1</td>
</tr>
<tr>
<td>Stopped Train</td>
<td>71.4</td>
</tr>
<tr>
<td>Car</td>
<td>71.2</td>
</tr>
</tbody>
</table>
The person *hears* 72.1 in the cockpit and 71.4 on the stopped train. The person *is exposed to* 83.2 in the cockpit and 92.0 on the train.
The person *hears* 72.1 in the cockpit, and 71.2 in the car.
The person *is exposed to* 83.2 in the cockpit, and to 100.8 the car.
Mink Farm

3 MW, Total Height: 150 m

Location 1

Location 2
Location 2

No rotation of WT
Windspeed: 0.5 – 1.5 m/s
Wind Direction: S SW
Temperature: 0-1 °C
Date: 16DEC16

WTs rotating
Windspeed: 4.0 – 6.5 m/s
Wind Direction: SW
Temperature: 6-8 °C
Date: 30DEC16
No rotation of WTs
Windspeed: 0.5 – 1.5 m/s
Wind Direction: S SW
Temperature: 0-1 ºC
Date & Time: 16DEC16

WTs rotating
Windspeed: 4.0 – 6.5 m/s
Wind Direction: SW
Temperature: 6-8 ºC
Date & Time: 30DEC16
Consequences of excessive infrasound and low frequency noise exposure: Vibroacoustic Disease (VAD)
1980
Portuguese Air Force
Aeronautical Plant

- Dr. CB is chief medical officer
- Observation of automatism in worker
- Evaluation of cases of epilepsy
- 10% of aeronautical technicians already diagnosed with late-onset epilepsy

Portuguese General Population: 0.2%
Neurological Changes

- Evoked Potentials: Measuring brain response time to a stimulus.
- Brain Mapping: Evaluates spatial distribution of brain potentials
- Brain MRI: Evaluates brain morphology and lesions
- Humor and Cognition: Increased aggressiveness, depression, memory and attention disorders

1980-1986
1987

Autopsy of Mr. Filipe Pedro

- 2 tumors (kidney and brain)
- Scars from 11 prior, silent cardiac infarcts
- Cause of death: 12\textsuperscript{th} small infarct (<2mm)
- Abnormal thickening of cardiovascular structures
- Pulmonary fibrosis

Pathology not restricted to Central Nervous System !!
Respiratory Pathology in VAD

In smokers and non-smokers alike:

- Bronchitis
- Repeated Throat Infections
- Unexplained Hoarseness
- Dry Cough
- Unexplained Cases of Pleural Effusion
1992

Begin using laboratory anomalous models

- Exposed to low frequency noise
- Occupationally-simulated schedule: 8 hrs/day, 5 days/week, weekends in silence

Caracterização do Ambiente Acústico da População de Estudo

<table>
<thead>
<tr>
<th>Frequência (Hz)</th>
<th>(dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>31.5</td>
<td>80</td>
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<tr>
<td>50</td>
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</tr>
<tr>
<td>60</td>
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<td>200</td>
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</tr>
<tr>
<td>800</td>
<td>80</td>
</tr>
<tr>
<td>1.25k</td>
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<td>2.00k</td>
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</tr>
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<td>3.15k</td>
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<tr>
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</tr>
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<td>12.50k</td>
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</tr>
<tr>
<td>20.00k</td>
<td>80</td>
</tr>
<tr>
<td>W</td>
<td>80</td>
</tr>
</tbody>
</table>
Alveolar Wall Thickening

The scale of these two micrographs is the same.
Normal Rat Trachea
Rat Trachea - 2213 hrs
Case of Environmental ILFN

The Irish Lady and the Dublin Bus company

**Bronchoscopy**: Appearance of “pink lesions”

**Voice Acoustic Analysis**: Fundamental frequency of three vowels significantly increases with increasing ILFN exposure time.
-- Cells are **not like elastic balloons** with floating organelles.

-- Cells communicate through biochemical and **mechanical signals**.

**Tensegrity:** Continuous Tension and Discontinuous Compression.
Tensegrity Structures

Cellular response to force along the vertical axis.

Cellular response to laminar flow.

Human Arm

Tensegrity model of cellular membrane pore

Ingber Lab
Harvard U.
ILFN effects on hearing

- **ILFN-Exposed People:**
  - Cannot stand any noise
  - Say: “I hear too much”
  - Lower TV volume to where others cannot hear it
  - Rage reactions
  - Audiograms show losses at 250 Hz and 500 Hz

- **ILFN-Exposed Rats:**
  Control rats respond to the sound of a blown kiss by becoming tense and frozen, while ILFN-exposed rats would develop a seizure-like episode, falling backwards while shaking.

**VAD TEAM:**
- Considers noise annoyance a **SUBJECTIVE PARAMETER**;
- In the presence of a “noise annoyed person”, prior noise exposure is suspected, and **OBJECTIVE MEDICAL TESTS** are provided.
Clinical Stages of Vibroacoustic Disease for Occupational Exposures (1999)

**MILD**

1-4 years of ILFN exposure

Slight mood swings, indigestion & heartburn, repeated mouth & throat infections, bronchitis.

**MODERATE**

4-10 years of ILFN exposure

Chest pain, back pain, fatigue, fungal & viral skin infections, allergies, blood in urine, inflammation of stomach lining.

**SEVERE**

> 10 years of ILFN exposure

Psychiatric disturbances, headaches, hemorrhages of nasal & digestive mucosa, duodenal ulcers, spastic colitis, varicose veins & hemorrhoids, decreased vision, severe joint pain, severe muscular pain, neurological disturbances.
VAD Researchers’ Experience:

• In-home ILFN levels have been much lower than within the occupational environments studied by VAD researchers.

• In-home time exposure patterns are different from occupational time exposure patterns: people sleep in ILFN-rich home environments.

• People most annoyed with in-home ILFN already have non-trivial noise exposure histories (fetal, childhood, leisure, previous or present occupations).

• The work-at-home person is more sensitive to in-home ILFN than other members of the family, unless these other members have additional ILFN exposure histories.
Cases of Environmental ILFN

(2004)

Cockpit vs. Restelo Home With Noise

Amplitude (dB)

Frequency (Hz)

cockpit  home with noise'

[Bar chart showing frequency vs. amplitude comparison for cockpit and home with noise]
Between 321 and 642 m from the home (2006).
November 2006

- Four 2-MW wind turbines (WT) began operation.
- Located between 321 m and 642 m.
- Family seeks legal advice.

2 adults.
2 children.

Farm for breeding:
-- bulls for bullfights,
-- thoroughbred Lusitanian horses.
March 2007

Letter from school-teacher:

“… it seems that [the child] has lost interest, makes a lesser effort, as if he were permanently tired. In Physical Education, an abnormal amount of tiredness is also observed. Is [the child] leading a healthy life? Does he sleep sufficient hours during the night?”

VAD TEAM is contacted by “Family R.”:

“… Inability to obtain restful sleep, increased irritability … Odd behavior of dogs, horses and ants … like an airplane flyover that never ends…”
In the Master Bedroom (2007)

Wind Turbine Home With Same Wind Speed (5.4 Km/h)

- Residual - Night (08/09Apr07)
- Environmental - Night (11/12Apr07)
- Environmental - Day (15Apr07)
Clinical Evaluation

P300 event related potentials in child

Jun 2007: 352 ms
Sep 2007: 322 ms
(norm: 300 ms)

PCO₂ respiratory drive

39-year-old father: 46%
42-year-old mother: 53% (norm: >60%)
Legal Proceedings - 2007

-- WT No. 2, closest to home, at 322 m was ordered shut down.

-- All other (3) WT's were ordered to be shut down during the evening (8-11 pm) and night hours (11 pm – 7 am).

-- Meanwhile, the installation of WT continued in the contiguous vicinity of the R family home.
Situation in 2010

-- Child has normal P300 values.

-- Mrs. R and the children have moved out of the home.

-- Mr. R. must stay to care for Lusitanian horses.

-- Mr. R’s health is visibly deteriorating, with increased cognitive impairment and severe noise intolerance.

-- Between 2000 and 2006, 13 healthy thoroughbred Lusitanian horses were born and raised on Mr. R’s property.

-- Horses raised after 2007 developed asymmetric equine flexural limb deformities (EFLD).

-- Four were studied plus 1 control.
During corrective surgery, fragments were removed for histological analyses. Results were the same as those from ILFN-exposed humans and animal models:

**Thickened vascular structures due to abnormal growth of collagen in the absence of an inflammatory process.**
Limb Deformities

VAD Team Laboratory
Rat exposed in utero

Wind Turbine Home Horses

Chicken exposed to Infrasound and Low Frequency noise generated by coal mining operations before hatching
Today

May 2013-- Supreme Court of Justice Decision:
   All 4 WT must be permanently removed;
   Increased monetary compensation.

Living arrangements:
   Mrs. R & children still live in separate home.

Mr. R’s health:
-- PCO$_2$ value at 28%
   (norm: > 60%; 46% in 2007)
-- Balance disturbances with loss of consciousness,
   apparently causing falls leading to facial and rib
   fractures. Suspected late-onset epilepsy.
Thank you for your attention!

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Succulent plant exposed to Northern winds on Madeira Island – North Atlantic Ocean.

Bronchial brush cell of Rat exposed to infrasound and low frequency noise.