



LATIN AMERICAN SYMPOSIUM ON RADON and
II SYMPOSIUM ON RADON IN BRAZIL

Towards a National Radon Program

May 19 - 23, 2019 - Poços de Caldas / MG
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RADON AS AN ALTERNATIVE METHOD IN THE INVESTIGATION OF ENVIRONMENTAL CONTAMINATION BY NON-AQUEOUS PHASE-LIQUIDS

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Secretaria Estadual de Desenvolvimento



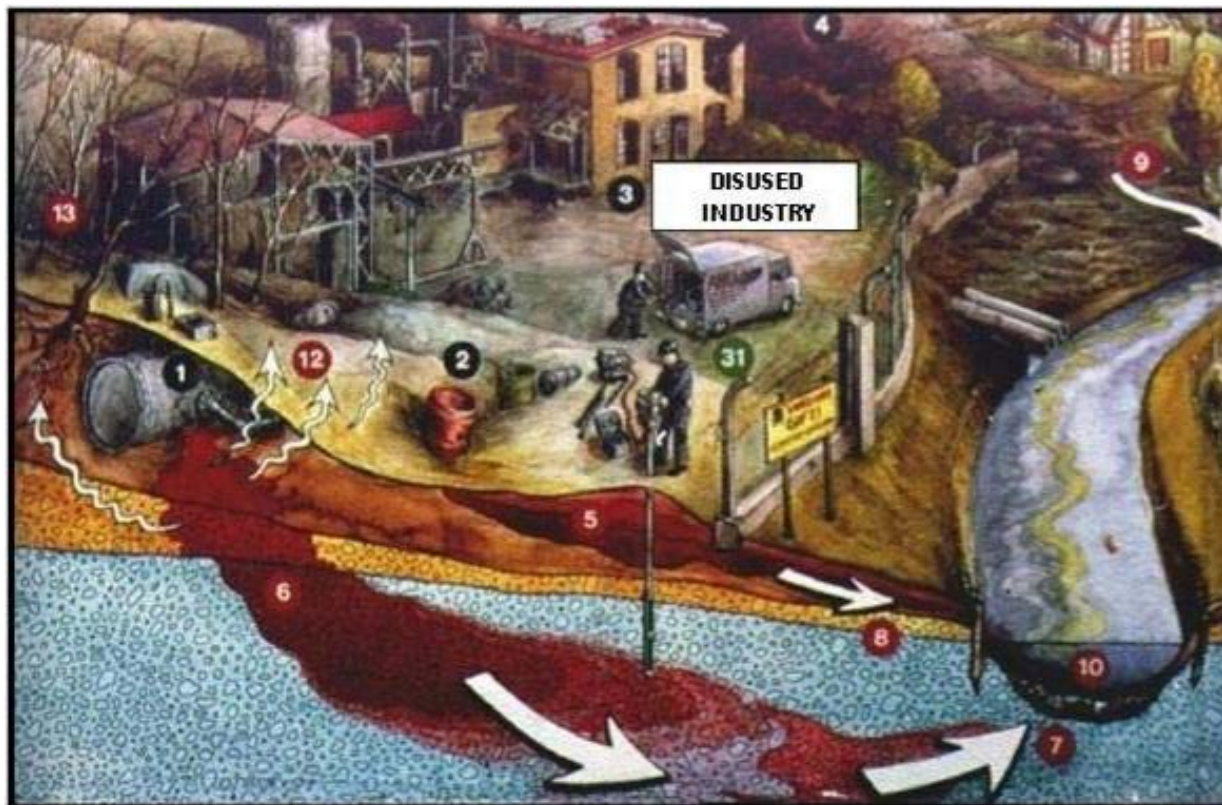
CNEN
Comissão Nacional
de Energia Nuclear

Ministério da Ciência,
Tecnologia e Inovação



Contaminated site

Definition: proven ground contamination area caused by the incorporation of any substance or waste that has been deposited, accumulated, stored, buried or infiltrated in a planned, accidental or even natural way (CETESB).



① to ④ sources of contamination; ⑤ to ⑬ pathways of contamination and ⑳ investigation

Motivation

- Contaminated sites may lead to risks to human health and ecosystems, restrictions to urban development and decrease of real estate value.
- December 2012: CETESB registered 4572 contaminated and rehabilitated sites in São Paulo state, 91.7% of which presented potential risk of contamination by NAPL.
- CETESB Management Manual states that hydrocarbons can be considered as "residents" contaminants once they are part of most industrial activities.
- Need to develop techniques that save time and investment for the identification of contamination and subsequent remediation.
- Traditional methods are expensive.



Legislation

- The National Environmental Policy established in the Brazilian Law No 6938 (1981), article §14, the protection of:
 - health and well-being of people, flora and fauna;
 - soil, water and air quality;
 - nature and landscape protection.

- The Brazilian Law No 6134 (1988) foresees the conservation of natural deposits of underground waters from São Paulo State; article § 4, namely: "the relevant State Agencies maintain essential services regarding underground water assessments, supervise its operation and take measures against the contamination of aquifers and deterioration of underground water."

NAPL

In a heterogeneous contamination of hydrocarbons and groundwater, the phase composed by hydrocarbons is called NAPL (Non-Aqueous Phase Liquid). There are two types of NAPL:

➤ LNAPL (Light Non-Aqueous Phase Liquids), with contaminant density lower than water density, and commonly associated with the production, refining and distribution of petroleum products (such as gasoline and kerosene).

➤ DNAPL (Dense Non-Aqueous Phase Liquids), with contaminant density higher than water density, and related to a wide variety of industrial activities. Examples of DNAPL are trichlorethylene, and other solvents.



Screening methods



Bailer with water and LNAPL (ConAm, 2013)



Groundwater contaminated by NAPL (ConAm, 2013)

The role of screening methods is to confirm or not the possible contamination in a particular area. The objectives are:

- to confirm the existence of contaminants;
- to identify the spatial distribution of contamination;
- to define a list of contaminants, obtaining average concentration values (semi-quantitative) for each contaminant and spatial distribution knowledge (hot spots).

Screening technologies most commonly used in Brazil

➤ portable gas chromatographs PID
(photo-ionization detector)
Phocheck Tiger.



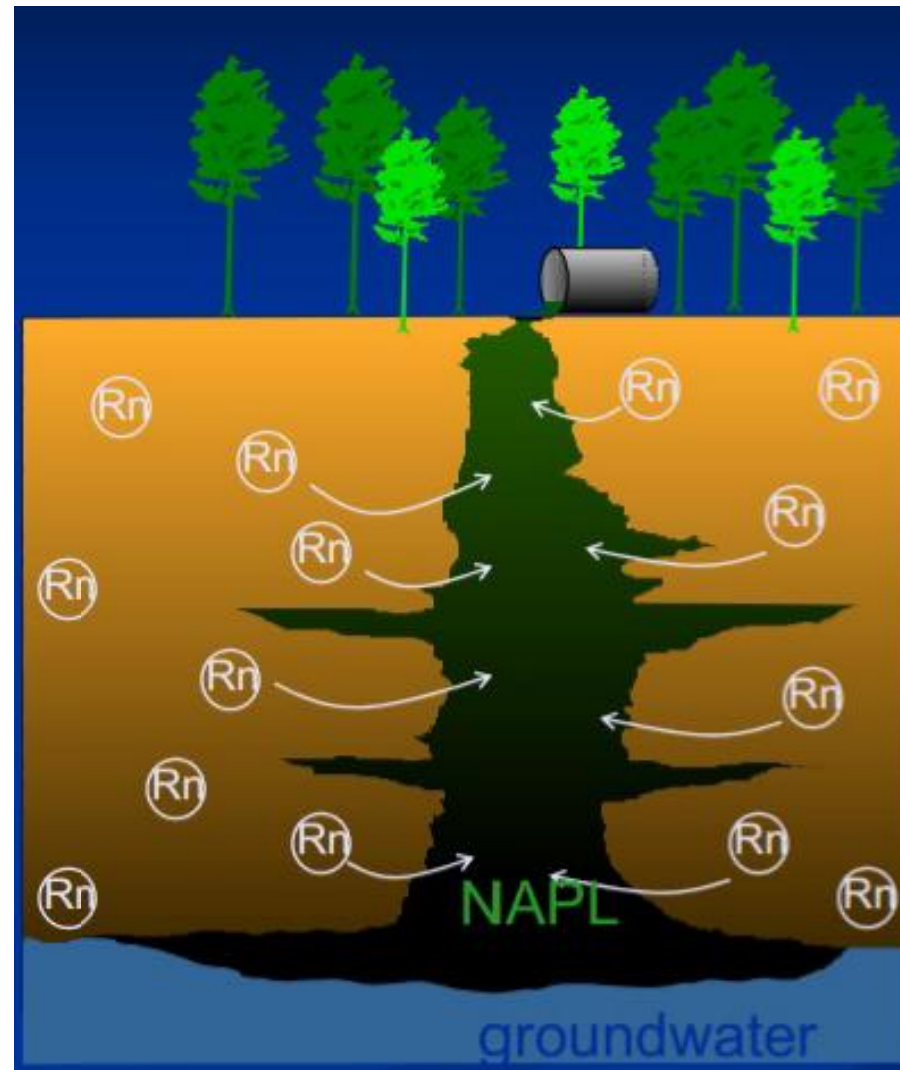
➤ sensors by catalytic oxidation
Innova (Soil Vapor Monitor)
Thermo Gastech® Company.



Behavior of ^{222}Rn in NAPL contamination

In the method proposed, the ^{222}Rn is used as an indicator for the analysis of subsurface soil-gas.

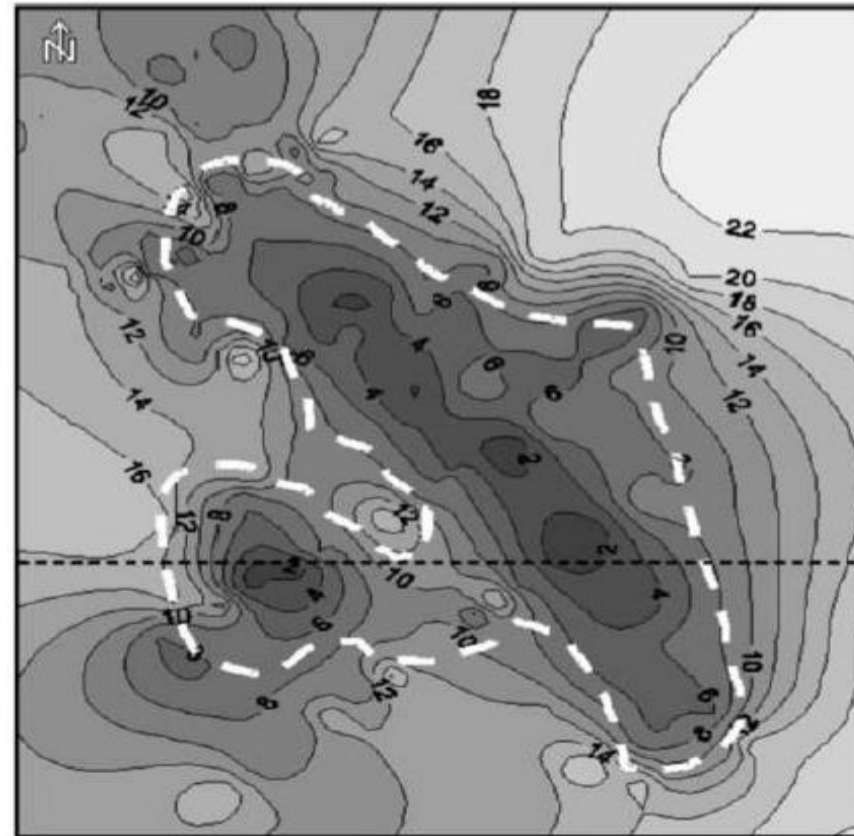
Radon has affinity with benzene, toluene and other organic compounds. Therefore, due to the high capacity of partitioning of radon in NAPL, which allows that the NAPL retain part of the radon previously available in the soil-pores, a decrease in the concentration of radon in the soil-gas is expected.



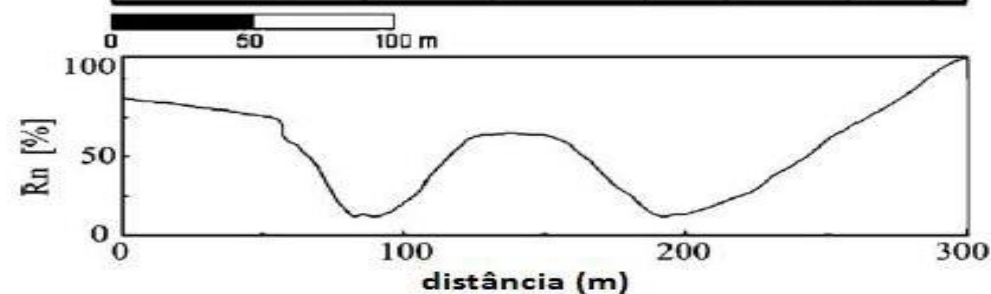
Behavior of ^{222}Rn in NAPL contamination

Example of localized contamination by measuring the activity levels ^{222}Rn

Distribution of radon ($\text{kBq}\cdot\text{m}^{-3}$) in soil-gas in a kerosene-contaminated area.



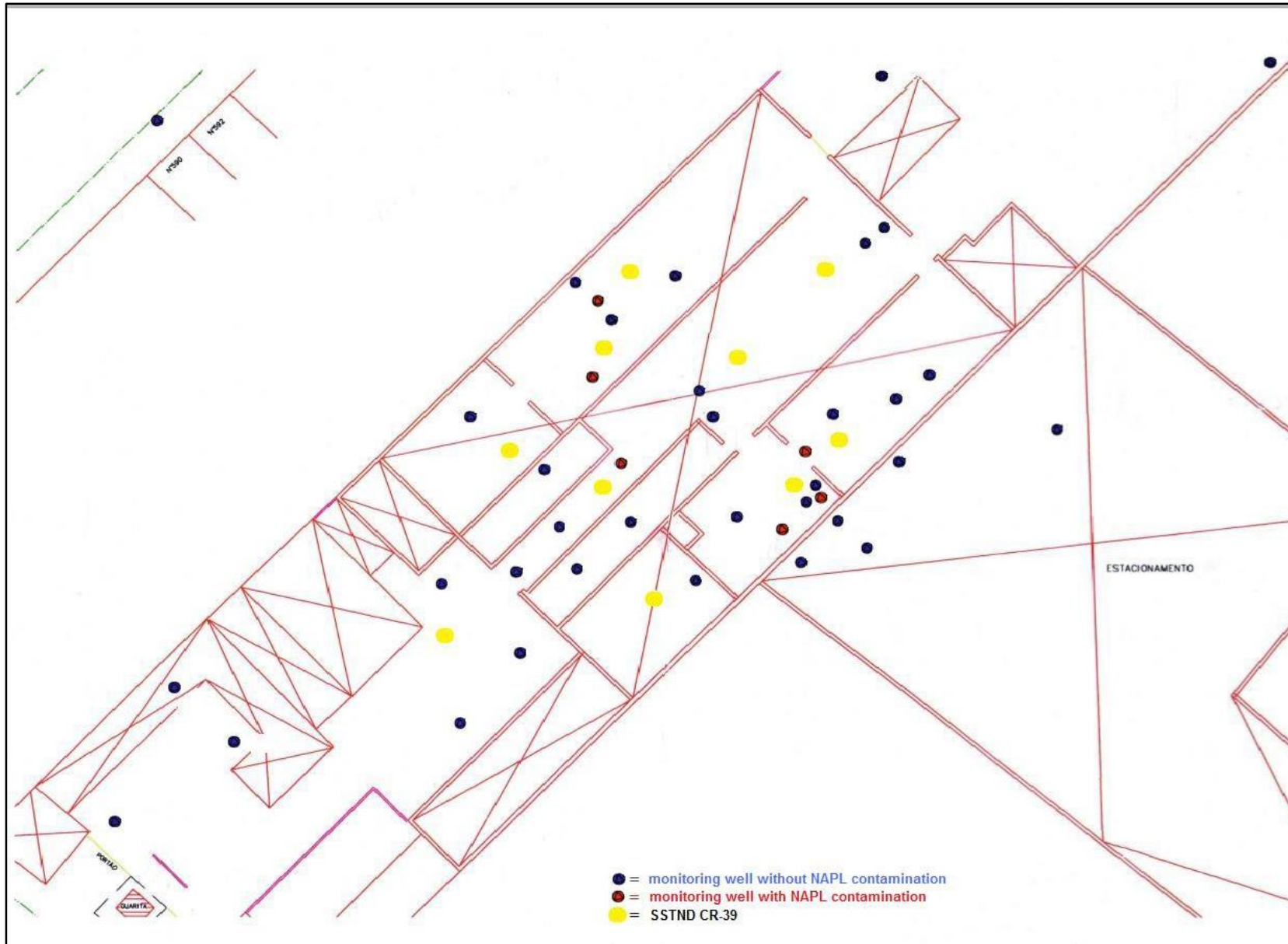
percentage variation of radon



Selection of a contaminated site

- previous indication of potential contaminants;
- to perform a confirmatory environmental research;

The methodology proposed in this study will be applied in a site with proven NAPLs contamination where, in the past, there was industrial use. Previous environmental surveys and installation of monitoring wells have identified the presence of light free phase LNAPL in the contaminated aquifer.



Experimental procedure

- passive detection with CR-39 inserted in a diffusion chamber NRPB/SSI
- The detectors will be exposed during a period varying between 14 and 30 days

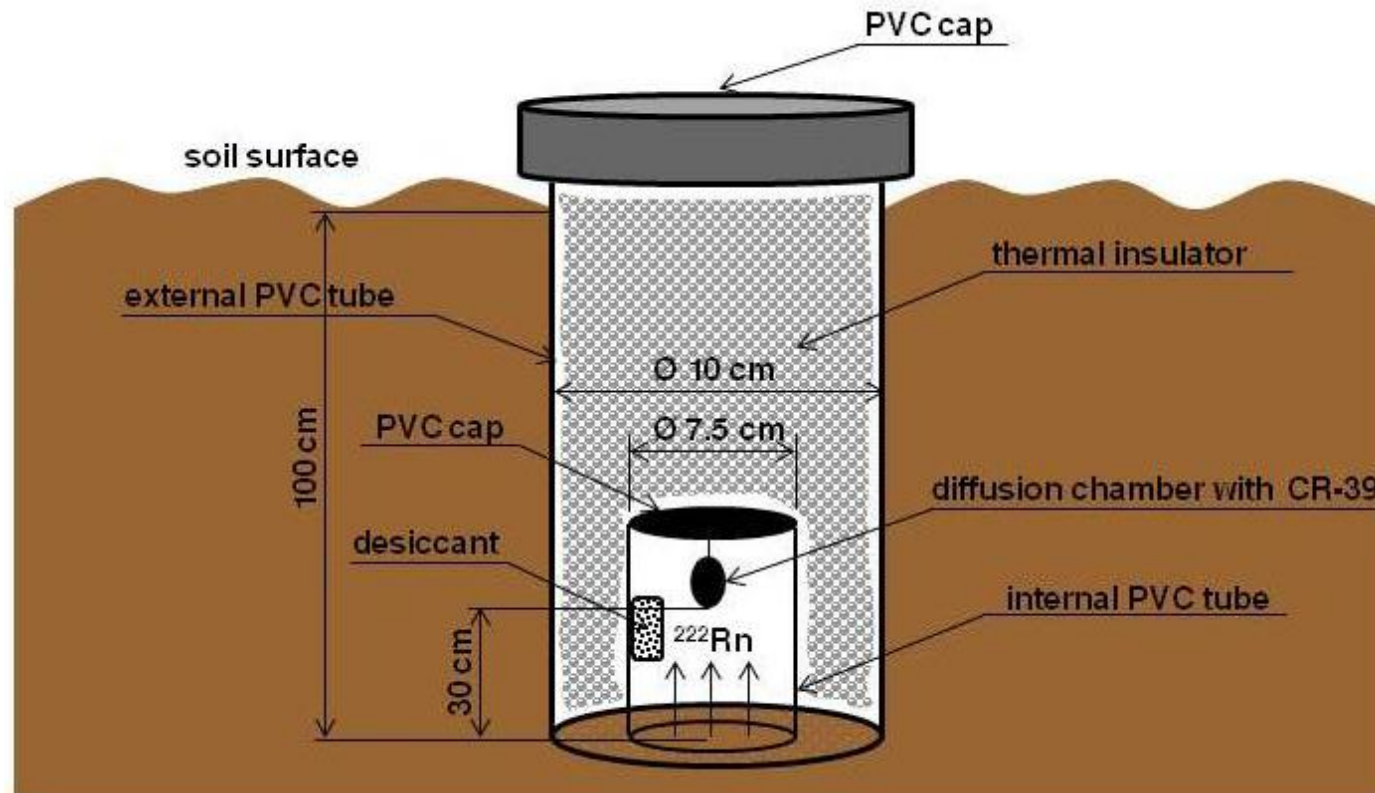


Diagram of the facility used for radon measurements in soil-gas



Radon activity concentration

After exposure, the CR-39 detectors will be returned to the Environmental Radiometric Laboratory, IPEN, São Paulo, etched and analysed under a Zeiss optical microscope.

Calculation of Radon activity concentration in air

$$C_{Rn} = \frac{D}{k.t_{ef}}$$

Where

C_{Rn} = radon activity concentrations in air (Bq.m⁻³)

D = net tracks density (tracks.cm⁻²)

k = calibration factor (tracks.cm⁻²/Bq.m⁻³.h)

t_{ef} = effective exposure time (h)



Important Considerations

- Etched and reading tracks protocol
- Calibration Factor
- Statistics
- Measures in the spring, summer, autumn, and winter

Conclusion

- Considering the effectiveness of SSNTD as a technique of passive measurement of radon gas concentrations in environmental samples, reliable results are expected in the present study.
- It will be possible to evaluate the applicability of the proposed methodology for Brazilian contaminated sites, as well as advantages and disadvantages over currently used technologies.

Acknowledgements



II Symposium on Radon in Brazil / May 19-23, 2014 / Poços de Caldas, MG, Brazil