USING THE IMAGE PRO PLUS TO COUNT A PARTICLES TRACKS IN CR-39

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INTRODUCTION

The presence of Naturally Occurring Radioactive Material (NORM) contaminating oil and gas facilities is a common fact in the petroleum industry and can be severe enough to expose the workers to high levels of radiation, mainly maintenance personnel.

NORM contamination is detected using radiation meters such as Geiger-Müller or scintillation probes. Gamma radiations are energetic enough to be detected, but alpha radiations emitted by radon and its decay products are not easily detected. A pancake probe is used on the contaminated surface for detecting alpha radiation from ^{210}Pb, ^{210}Bi and ^{210}Po.

A widely used technique for radon detection is a passive method that employs Solid State Nuclear Tracks Detectors - SSNTD. One of the most used detectors is CR-39 the trademark for allyl diglycol carbonate, C_{12} H_{18} O_7. The detection method consists in counting, with the aid of an optical microscope, the tracks resulting from the interaction of alpha particles, or positive charged particles, with the plastic (CR-39). [1,2] Computer tools are used to count those tracks.

The objective of the present study was to report the application of the software Image Pro Plus in nuclear tracks counting, from the emanations of radon present in samples from NORM. The images of α particles tracks emanated by ^{222}Rn, registered on CR-39, were observed with a Nikon E400 optic microscope and captured by a Nikon Coolpix digital camera and then stored in a database, to later count the tracks using the computational program, Image Pro plus. Since the number of those tracks resulted proportional to the emanation rate of ^{222}Rn this methodology allowed the comparison of contamination levels in analyzed samples.

MATERIALS AND METHODS

Radon Detection and Measurements

Radon exhalation was evaluated with a measuring system composed by a cylindrical tube (Figure 1) and a diffusion chamber (Figure 2) containing a solid state nuclear track detector (SSNTD), where the samples remained for 7, 14 and 30 day-periods. CR-39 was chosen as detector due to its high efficiency and advantages already known. That counting was performed through a semi-automated process which consists in counting the number of alpha tracks due to NORM present in the sample, determined with the aid of a computer program after capture of the images registered on the detector, using an optical microscope and a digital photographic camera coupled to a computer.

Experimental Procedures

Latent tracks can be made visible under an optical microscope by chemical etching, which is the most widely used technique to increase the latent track in solid state nuclear track detectors. [3]

In this experiment, the conditions adopted to determine the exposure of CR-39 to ^{222}Rn exhaled by the samples over 7, 14 and 30 days , follow the processing stages: the CR-39 detectors were chemically etched using 6.25 N NaOH solution at 70°C for 5 hours in thermal bath [3,4]; after chemical etching, the visualization of the tracks produced by the α particles was obtained with a NIKON E400 optical microscope with the following enlargements: ocular lens10x and objective 40x; Then, the track images were captured with a COOLPIX 995 digital camera manufactured by Nikon (Figure 3). [5]

Finally, the number of tracks due to the NORM contained in the samples was determined with the aid of Image Pro plus 6.2 Processing & Analysis Software (Figure 4). [5]

Image Processing and Analysis

The image processing itself covers various topics such as image enhancing, filtering, restoration, analysis, reconstruction from projections, and compression. [6]

Pre-processing techniques are applied to the image to obtain an image with enhanced characteristics, more adequate for the next processing stages. There are various image enhancing techniques. [6]

Among the Image Pro Plus available resources, some functions stood out because they enabled track counting at a higher speed .Initially, the "Enhance-Equalize-Best Fit", was used to improve image enhancement. Next the filter "Process-Filters-Enhancement-HiGauss", a Gaussian function that reduces image noise, was applied. After this pre-processing, two morphologic operators were applied: "Erosion and Dilation". The "Erosion" operator was used to remove irrelevant details and opening intervals in regions of unwanted connection. The "Dilation" operator was mainly used to fill unwanted gaps in the image. Finally, track counting is done in the "Count /Size" function, with the following parameters and respective functions:

"smoothing" – smoothing to remove details, smoothing the borders.

"Fill holes " – fills the holes of the objects.

"Select Measurement-area" – delimits the area where the objects are counted.

"Watershed Split" – segmentation by watersheds applied to extract and separate objects with features slightly uniform from the image background.

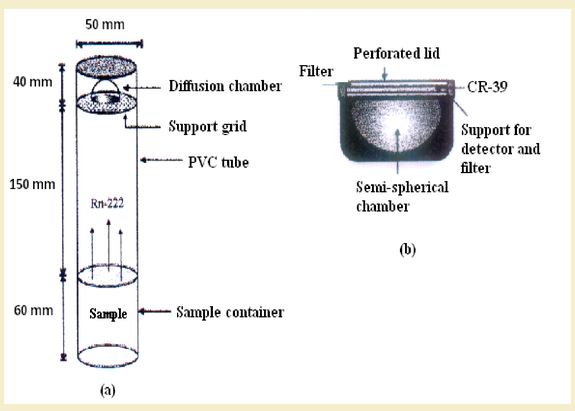

Figure 1. Experimental Arrangement: (a) Detailed view of PVC tube and (b) Detailed view of diffusion chamber

Figure 2. Diffusion chamber details: (a) CR-39 detector; (b) filter; (c) perforated lid; (d) support for detector and filter and (e) semi-sferical chamber

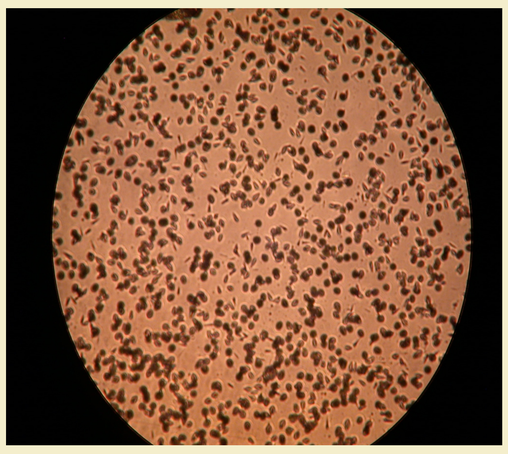

Figure 3 – Images of tracks from alpha particles, observed in Nikon E400 optical microscope with 400 times enlargement

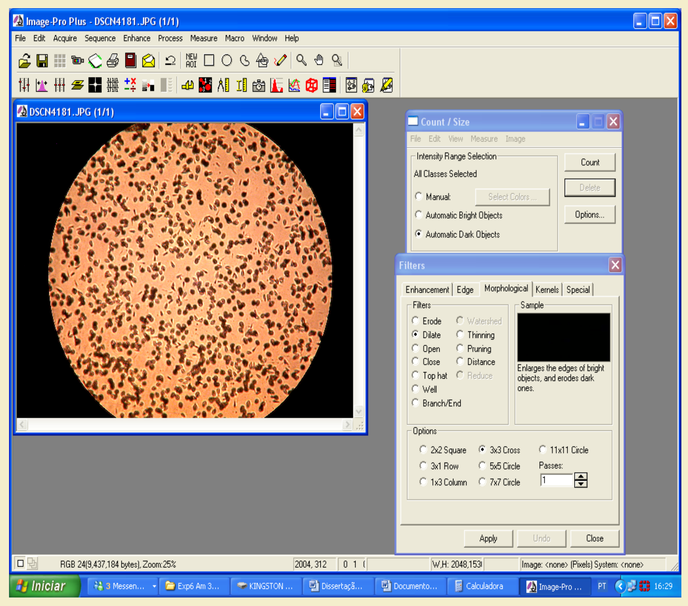

Figure 4 – Image obtained after digital processing performed with Image Pro Plus and general view of the screen supplied by this computer program

RESULTS

After a period of exposure of CR-39 detectors to the α particles from ^{222}Rn contained in the samples Sp 1, Sp 2, Sp 3 and Sp 4 for 7 days , 14 days and 30 days, the surface densities of the tracks (number of α particle tracks in 1 cm^2 of detector) were recorded and also those correspondent to background radiation, using the diffusion camera with the CR-39 and a filter for periods of 7, 14 and 30 days, respectively, totalizing three experiments: BG 1, BG 2 e BG 3, that are shown in Table 1.

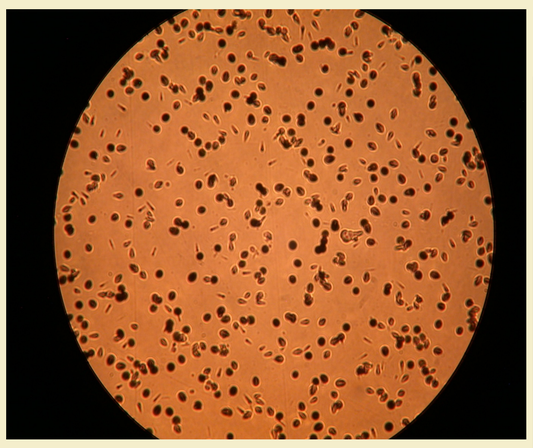

Figure 5 – Image of alpha particle tracks related to one of the analyzed NORM samples

Table 1 – Surface densities of tracks of α particles emitted by ^{222}Rn contained in the samples: Sp 1, Sp 2, Sp 3 and Sp 4.

Sample	Exposure (days)	Track Density (#tracks/cm^2)	Exposure to ^{222}Rn [kBqh/m^3]
Sp 1	7	2313 ± 151	228.18 ± 35,97
	14	6541 ± 427	768.46 ± 95,24
	30	6591 ± 430	468.85 ± 115,97
Sp 2	7	2476 ± 161	256.10 ± 37,69
	14	4649 ± 303	444.36 ± 74,00
	30	3930 ± 256	13.02 ± 86,16
Sp 3	7	393553 ± 25660	67247.60 ± 4405,66
	14	788549 ± 51413	134726.43 ± 8829,14
	30	1113175 ± 72579	190026.70 ± 12475,09
Sp 4	7	18863 ± 1230	3063.20 ± 220,81
	14	31896 ± 2080	5111.80 ± 378,40
	30	54074 ± 3526	8602.70 ± 646,31
BG 1	7	911 ± 59	-
BG 2	14	1985 ± 129	-
BG 3	30	3784 ± 247	-

CONCLUSIONS

The comparison of the mean of track counting obtained by manual method with that obtained by automated method shows that the Image Pro Plus program is adequate for counting tracks from alpha particles emitted by ^{222}Rn present in the samples contaminated by NORM.

The method proved to be efficient for the analysis of the samples focused in this research when the concentration of alpha particle tracks is low or medium and the tracks have a well defined morphology. However, when the sample has a high concentration of tracks and with different morphologies, the methodology shows limitations. In this case, we suggest the use of Artificial Intelligence techniques to eliminate spurious countings.

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