New Experimental Method for Measuring the Bone Mineral Density of the Bone

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Abstract

In this paper, we present experimental results measuring bone mineral density Average (DPMH) for human remains. The above results were obtained considering the application of a mathematical model as the DPMH nonlinear function of parameters such as temperature, relative electric permittivity and variables as calcium transfer between bone and the periphery, and voltage resonance frequency, measured with an electronic device in the University Central designed by the research group ESSOPTO and bones using as dielectric material between the plates of a flat plate capacitor. Then on destructive capacitive electronic circuit compares the frequency behavior of the bones, with a reference capacitor sampling as electronic element.

Key words: Average Mineral Density, Bones, dielectric material.

1. Introduction

1.1. Exposition of the problem

In the experimental processes reported in (Suby, J. A.,2006; Guy, T. et al.,2005), the determination of the Average Mineral Density of Bones AMDB, there are in use destructive technologies that they carry to establishing values of the AMDB of a local way, without it could include the characterization of the properties electro mechanical, and inclusive electromagnetic of the bones as dielectric material. Though it is true that the AMD Breflects in it the behavior of the mechanical resistance and the properties of transfer of calcium of the bone with the periphery, also it reflects the thermal expansion and the molecular structure of this class of materials. At present the experimental technology most used and accepted by the majority of the laboratories and producing companies of medical equipment for the determination of the AMDB, is the dual technology energy X - ray absorptiometry. This technology apart from being highly harmful according to the time of radiation exposure, does not offer any other information on the electromagnetic properties of the above mentioned compounds as: electrical and thermal conductivity σ_e, σ_T impedance Z, magnetic susceptibility χ, between others.

2. Theoretical model

Departing from the theoretical developments presented by(Nadya, U.2004) and (Hakulinen, M. A. et al.2003) for the calculation of the electrical permittivity of dielectric material (particular case ceramic material), the behavior of the AMDB as a function of multiple variables, between them: CI - inorganic component, V - voltage generated by the samples under the action of an electrical uniform field, ε - electrical permittivity, w - resonance frequency, between others; it has been one of the principal aims of study of the group of investigation ESSOPTO in the Central University in last two years.

To be able to determine the value of the AMDB for samples of osseous material, so much theoretical as experimentally, a model proposes of capacitors in series, constituted by the material to analyzing, the plates or armors of the capacitor and the air that one could present between them.

The value of the AMDB to calculating would be:

$$\text{AMDB}=\frac{k_H k_S d_H d_S (CL_T - A\epsilon_0)}{CL_T (X(\epsilon_0 (k_H d_H - k_S d_S) + k_H k_S (d_S - d_H)) - k_H d_H (\epsilon_0 - k_S))} \quad (1)$$

Where: ε_o - electrical permittivity of the air; k_H - electrical relative permittivity of the water; k_s - electrical relative permittivity of the solid one; L_T - total distance between plates of the capacitor; *A* - area of one of the plates of the capacitor.

For the previous thing, the value of the AMDB like distribution function will have the form:

$$\text{AMDB}= f(CI, w, V, \varepsilon, d...) \quad (2)$$

Where: d - thickness of the sample.

In this model, it is necessary bear in mind that the material is a phase configuration (air / solid, solid / solid, water/air) and that the physical properties previously mentioned change in every direction of movement in the material. For the previous reason, the vector of polarization will depend of: CI - inorganic component, degree of porosity, degree of transfer of calcium of the bone with the periphery, the AMDB, electrical permittivity and temperature

3. Experimental procedure

The previous theoretical model for the experimental development of the present work, initially took as values of reference of the AMDB information of (Rodríguez, O,2003;Han, S. M. and Davis, J. A1997), which later were compared by the obtained ones by the method proposed in the formless present for different samples of human osseous remains as: cranium, scapula, ulna, radius, pelvic girdle and average ribs. The number of samples, ten of each one, changed per date and region where they found the remains. A group of samples was obtained of the Cemetery of the south of the city of Bogota, and the second group of the Saw of the Perija, Department of the Cesar - Colombia. On having compared the experimental information of the behavior in frequency of the AMDB for long bones as the femur (figure to see 2), with the values obtained by the method of simulation, one found a diversion of the curves in 4,18 %, which the mathematical model led to correct in terms of the thickness of the samples. After the alteration done to the model, they returned to take information of the AMDB for the same bones and returned to compare the results, meeting a diversion of 1,8 % between curves. Later there measured up other human osseous remains under the same parameters and there were obtained the figures (3, 4, 5).

4. Analysis of results

The values obtained of the AMDB by the dual method energy X - ray absorptiometry, and for the electronic capacitive method, summarize in the behavior of the figure 6, hereby, the long bones prove the densest, followed for vertebral elements and finally flat and irregular bones where the horizontal axis corresponds to the resonance frequency.

In both previous ones, figures 1 and 2, sees the influence of the frequency in the behavior of the AMDB calculated by the electronic capacitive method without there exists of for way a toxic or dangerous method for the user, since it is the case of the use of the dual method energy X - ray absorptiometry.

The dynamic behavior of the material in the range from 10 to 200 KHz, gives like proved initially, the activation of normal manners of oscillation of the dipoles of the structure of the H_2O near to 21.4 KHz, and later for effect of collision, the activation in the measure of the increase of the frequency of the dipoles of the net in strict sense.

5. Discussion of results

Having in counts the hypothesis raised in the theoretical frame on the anisotropic behavior of the osseous samples, object of study, the figures 1 - 4 demonstrate the behavior of the AMDB without the adjustment to the theoretical raised model, whereas in the figures 5 and 6, the curves follow the same path and trend, applying the model, this is achieved fitting the value of the resonance frequency for every sample.

6. Conclusions

By his anisotropic structure, to think a specific form of distribution of the osseous structure is not adapted, for what the process of polarization that is generated to the interior of the samples, does that the electromagnetic sign gets depressed in such a way that this makes change the resonance frequency with the distance of tour of the electrical field in the sample, which in other words, comes closer the thickness of the same one. The previous thing generates a not homogeneous distribution of the energy in the volume of the osseous samples, driving to make change this way the AMDB of the same ones.

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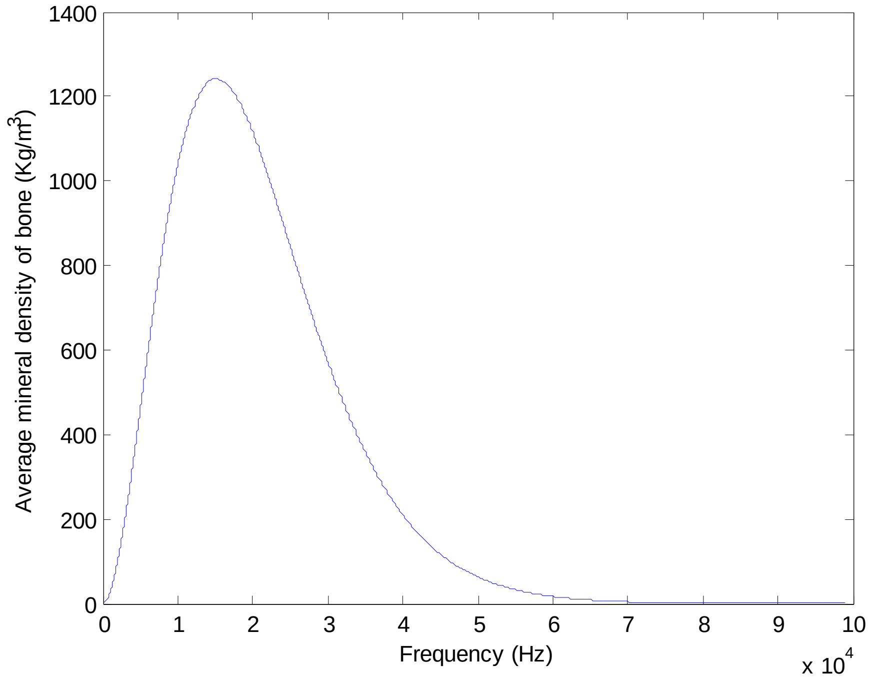

Figure 1:Behavior of the theoretical frequencyfor DPMH human skeletal remains, in the case of long bones such as thefemur.

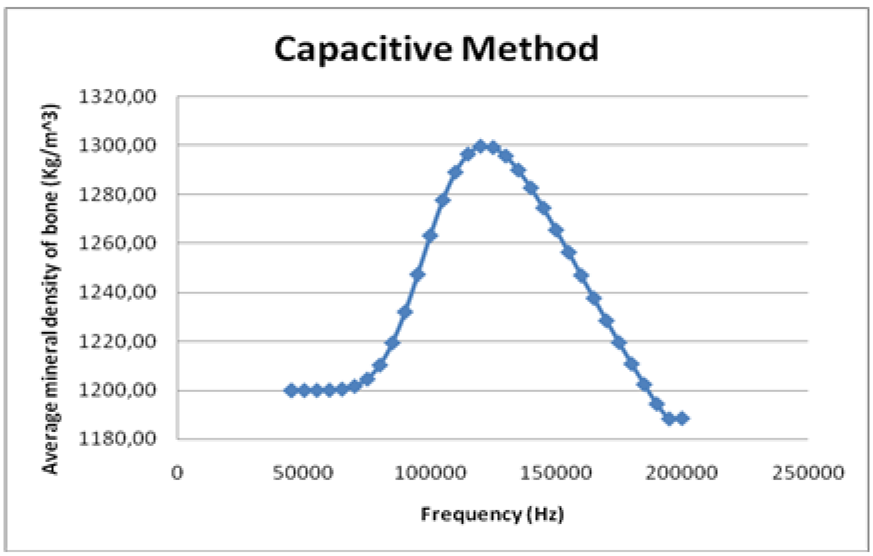

Figure 2:FrequencyBehaviorofexperimentalDPMHforhumanskeletalremains, for the cemetery femurs ou the rnexhumed Bogotá.

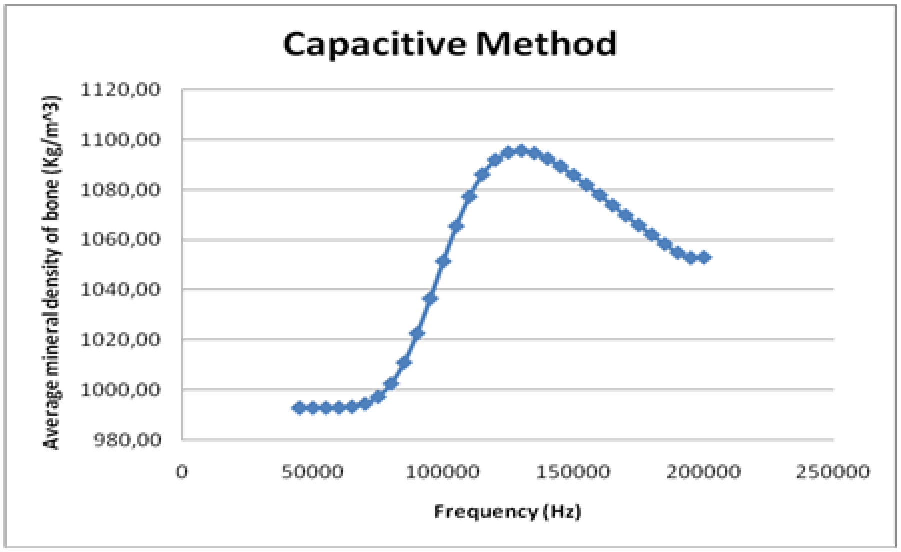

Figure 3: Experimental behavior in frequency iliac DPMHexhumed from the cemetery to the south Bogota.

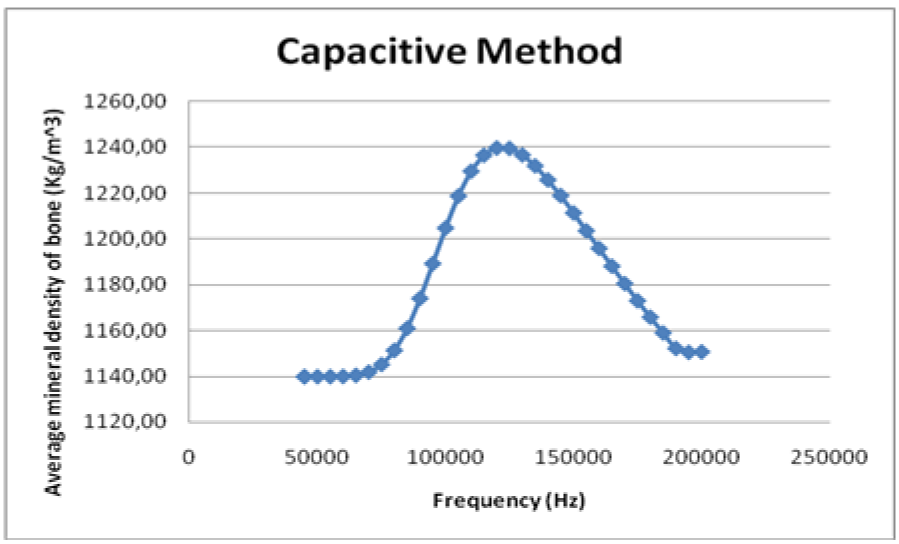

Figure 4: Experimental behavior in frequency DPMHulnaex humed from the cemetery to the south Bogota.

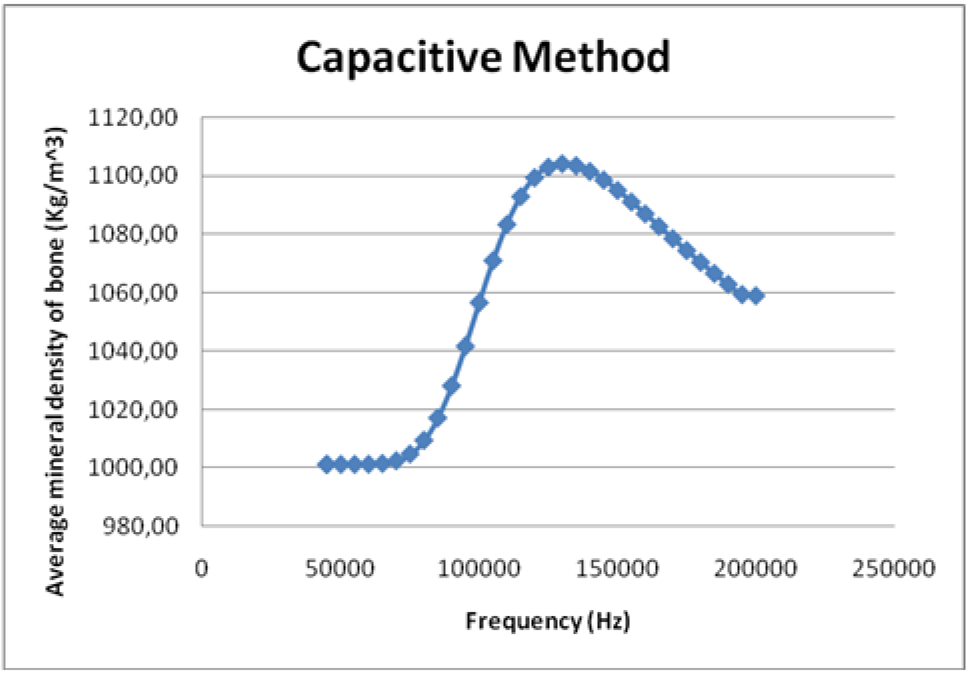

Figure 5: Behavior frequency experimental DPMH skullex humed from the cemetery to the south Bogota.

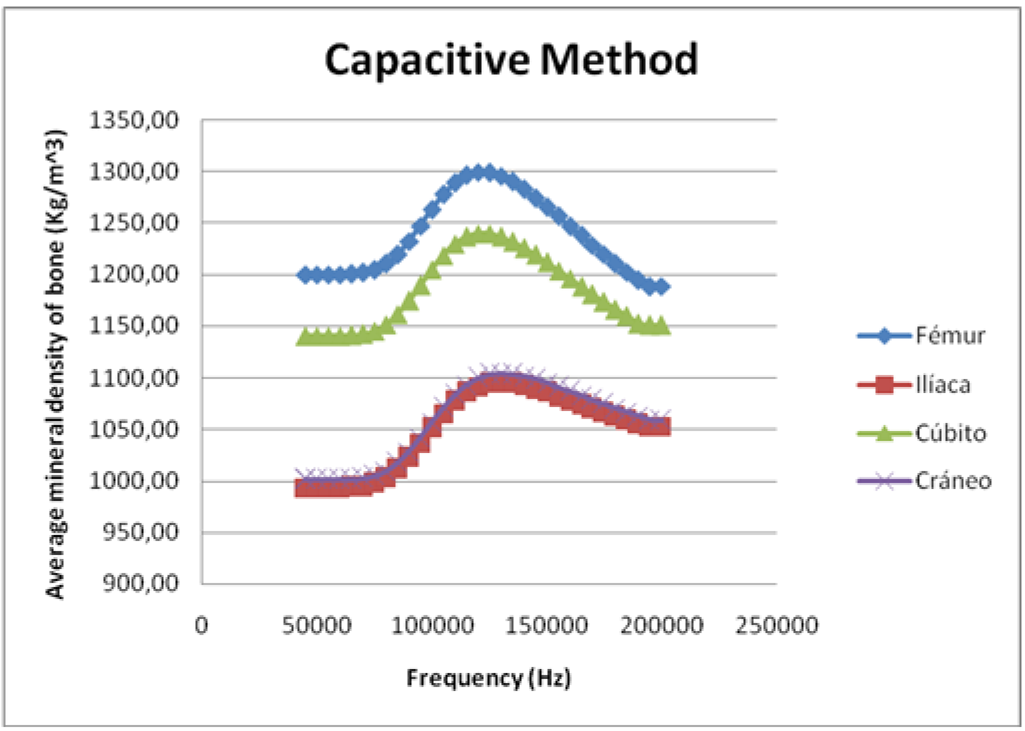

Figure 6: Comparison of the DPMH frequency for several groups of samples of human skeletal remainsunder the same measurement conditions and experimental parameters.