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In-Vitro Studies of Artificially Removed Human Renal Stone Minerals by Sonic Engineering Approach-I

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ABSTRACT

Ultrasonic waves are the main tools for measuring the unknown parameters in science and technological analysis of a particular biological sample. The sonic wave velocity measurement applied in the in-vitro & in-vivo studies in medical fields has been made in different renal stones removed from the human kidney. The samples were analyzed at different frequencies and the corresponding wavelength at room temperature (305K) were found. The experimental results have been used to calculate many physical constants of the samples, such as stone density, sonic velocity, acoustical wavelength, specific acoustic impedance, transmitivity, reflectivity and dynamic modulus of elasticity. The investigated results have been agreed to the reported information.

***Key Words**: Mineral processing, Sampling, Process instrumentation, Bio-oxidation, Ion exchange*

1. INTRODUCTION

The ultrasonic sound velocity gives the necessary data in all the states. From the sonic velocity of a particular medium and its propagation results, one can find the texture, structure, porosity, compression, and particle size in a direction, which is kept at constant physical and chemical environments. More number of parameters can be calculated in solids [1-2] and hence it is applied to the human physiological disorders. Ultrasonic wave velocity has been used in conventional medical diagnostics therapy and surgical tools in different sensitive parts of the human body such as brain, glands, breast, heart, urinary tracts, peripheral blood vessels, reproductive organs, etc.[3-5]. Especially in a human physiological system, kidney is a major organ, which separate extra minerals, water, wastes etc. from the blood after digestion. In the pathological condition let the kidney failure, inhibitor disorder, and increase in mineral values in the blood or urine continuously, one can get the renal stones any where within the urinary tracts. The kidney stone formation, or renal stone diseases or mineral deposition or crystals grown in the kidney creates socio-economic disorders. To avoid this type of problem one must clearly know about the diseases to prevent the deposition either before the start or after the start. Extra corporeal shock wave lithotripsy (ESWL), Laser and UV has created large disadvantages such as tissue damage, pain etc. [6-8] which can be overcome by ultrasonic method of treatment [9]. In the present investigation, the longitudinal sonic parameters of six different kidney stones at different frequency ranges from 0.5MHZ to 12 MHZ at 305K were used.

2. MATERIALS AND METHODS

Many methods are used to measure the ultrasonic parameters in the biological system. In the present investigation, pulse echo overlap (PEO) technique was used with the good accuracy. The PEO method is applied in diagnostic purpose as well as the tissue characterization in a static and dynamic system. A double probe contact (between the kidney stones) through transmission technique was used for the measurement of this parameter. The transmitter, receiver transducers are controlled by the computer. Similar studies have already been carried out in gallstones [10]. From the observation, it gives directly the parameters of pulse transit time (t) for the known thickness (d). Using the available data the acoustical impedance (Z), density (p) of the samples, pressure amplitude coefficient (R), pressure amplitude transmission coefficient (T) and dynamic modulus of elasticity (E) of all the samples were calculated.

In the present studies different types of stones were collected in and around Namakkal District local hospitals in Tamil Nadu. India. The stones were named as A, B, C, D and E. The stones were removed from the kidney by applying the ultrasonic lithotripsy process. The samples were collected, cleaned and then preserved. The chemical compositions of all the samples were by bio-chemical methods. The constituents of the samples are tabulated in Table-1. In this study, it is assumed that in-vitro calculation gives good representation of the natural properties of the biological stones and characteristics of the vivo solution.

3. RESULTS AND DISCUSSIONS

The artificially removed renal stone samples were photographed using digital camera and find its dimensions. The renal stone samples are shown in Fig.1-5. Samples were analyzed by bio-chemical methods to identify the chemical constituent present in the samples. The corresponding samples composition and its various types of stones are shown in Table-1. The various parameters of the stones, such as mass, size, volume and density are presented in Table-2. It is clear that the B sample has more density and less volume than the sample D. The frequencies and wavelength of the corresponding samples at particular velocity of the ultrasonic samples at constant temperature were recorded in Table-3. From the data, the frequency and wavelength is inversely proportional to each other. The specific acoustic impedance of all the samples were calculated and recorded in Table-4. With reference to the density of air medium, and ultrasonic velocity then acoustical impedance of the medium, the reflectivity, transmitivity were calculated and recorded in Table-5. The dynamic elasticity of the renal stones at room temperature (305K) were calculated and recorded in Table-6. Densities of the samples are directly proportional to the dynamic modulus of elasticity [11].

Fig.1-5 Renal stones

Table-1 Chemical composition present in the renal stones

Stones Name	Stones Colure	Chemical compositions presents in the Renal stones
A	Brownish blue	Calcium oxalate di-hydrate, calcium phosphate.
B	Light yellow	Calcium oxalate monohydrate, Calcium oxalate di-hydrate.
C	Yellowish brown	Calcium oxalate monohydrate with Phosphates.
D	White yellow	Calcium oxalate monohydrate, Phosphate, Calcium oxalate di-hydrate.
E	Brownish white	Calcium oxalate monohydrate

Table-2 Density calculation of artificial removal of renal stones (six stones)

Stones Name	Mass of the Stones X 10^{-3} Kg	Dimension of the Stones (mm) X 10^{-3} m	Volume of the stones (V) m^3	Density of the stones kg/m^3 (ρ)
A	0.429	5x6x5	$2340x10^{-9}$	2860
B	0.4104	6x4x5	$91.125x10^{-9}$	3426
C	0.325	5x5x5	$76.5x10^{-9}$	2602
D	0.065	6x2x2	$27x10^{-9}$	2701
E	0.09	3x5x3	$60.75x10^{-9}$	2202

Table- 3 Variation of wavelength (in mm) with frequency change of artificial removal of kidney stones (longitudinal wave)

Stones Name	Density of the stones kg/m^3(ρ)	FREQUENCY in MHZ									
		0.5	2	4	5	6	7	8	9	10	12
A	2860	1.099	0.275	0.137	0.109	0.092	0.079	0.069	0.061	0.055	0.046
B	3426	1.053	0.263	0.132	0.105	0.088	0.075	0.066	0.058	0.053	0.042
C	2602	1.315	0.323	0.165	0.132	0.111	0.094	0.082	0.073	0.066	0.055
D	2701	1.319	0.33	0.165	0.131	0.110	0.094	0.082	0.073	0.066	0.055
E	2202	1.320	0.301	0.165	0.132	0.110	0.094	0.083	0.073	0.066	0.055

Table- 4 Specific acoustic impedance of the renal stones

Stones Name .	Volume of the stones (V) 10^{-9} m^3	Density of the stones(ρ) Kg/m^3	Velocity of the Ultrasonic wave m/sec	Specific acoustic Impedance (Z) Z=(ρ x c) X10^6 ohms
A	150	2860	549.9	1.9994
B	120	3426	526	1.9995
C	125	2602	657.9	1.9995
D	24	2701	659.3	1.9995
E	45	2202	660.1	1.9994

Table-5 Reflection co-efficient and transmission co-efficient of the renal stones

Density of air=1.26 Kg/m^3.
Acoustic impedance of air (Z_1) = 425.7.
Velocity of ultrasonic in air =330 m/sec

Stones Name.	Volume of the stones (V) 10^{-9} m^3	Density of the stones(ρ) Kg/m^3	Velocity of the Ultrasonic wave m/sec	Specific acoustic Impedance Z=(ρxc) X10^6 ohms	Reflectivity (R)	Transmitivity (T)
A	150	2860	549.9	1.9994	0.9995	1.9994
B	120	3426	526	1.9995	0.9995	1.9995
C	125	2602	657.9	1.9995	0.9995	1.9995
D	24	2701	659.3	1.9995	0.9995	1.9995
E	45	2202	660.1	1.9994	0.9994	1.9994

Table-6 Dynamic modulus of elasticity of the renal stones (E)

Stones Name	Volume of the stones (V) 10^{-9} m^3	Density of the stones(ρ) Kg/m^3	Velocity of the Ultrasonic wave m/sec	Specific acoustic Impedance (Z) Z=ρ x c X10^6 Ohms	Dynamic modulus of elasticity of stones (E) x 10^{10} Nm^{-2}
A	150	2860	549.9	1.9994	0.4496
B	120	3426	526	1.9995	0.6174
C	125	2602	657.9	1.9995	0.4455
D	24	2701	659.3	1.9995	0.4810
E	45	2202	660.1	1.9994	0.3202

4. CONCLUSIONS

From these investigations, one can understand the chemical constituents present in the samples, the ultrasonic velocity, specific acoustic impedance, reflectivity, transmitivity and dynamic modulus of elasticity of all the samples. All the observed data in this study are in close agreement with the results of earlier workers in gallstones. The results give the necessary information about the ultrasonic propagation in different types of renal stones. The in-vitro information helps the identification and understanding of the future in-vivo studies.

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