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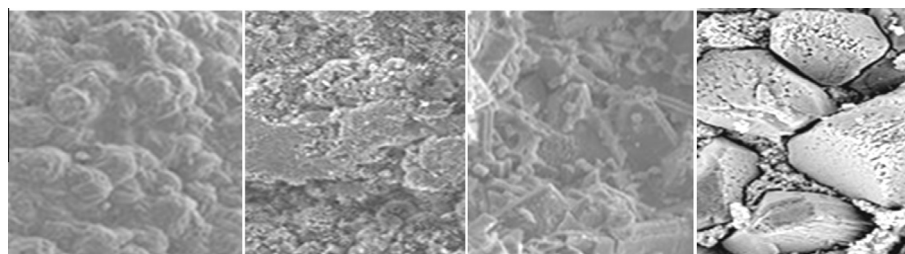
## Physicochemical analysis of urinary stones from Dharmapuri district

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### HIGHLIGHTS

- Incidence of urolithiasis and skeletal fluorosis are high in the investigated area.
- The samples were analyzed mainly by IR, Raman and ED spectroscopy.
- The analyses revealed the stones to be COM, uric acid, struvite and mixed stones.
- The toxic elements such as zirconium and mercury were identified in stones.
- The enhanced hardness of the stones due to the presence of zirconium.

### GRAPHICAL ABSTRACT



Spherulitic crystals in calcium oxalate monohydrate

Rough surface of uric acid stone

Platy crystals of mixed stone

Pyramidal shaped struvite crystals in the periphery of the stone

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### ABSTRACT

Nephrolithiasis is a common disease caused by the multifactorial components such as geographical location, bacterial infection, low urine volume, and low intake of water. This disease induces severe metabolic abnormalities in the human body. As the prevalence of this disease was high in Dharmapuri district located in Tamil Nadu, urinary stones removed from the patients pertaining to this district were collected and to identify the toxic elements present in the stones. The presence of functional groups and phases of the stones were analyzed using X-ray diffraction (XRD), Fourier transform Raman spectroscopy and Fourier transform infrared spectroscopy (FT-IR). The majority of stones were found to be calcium oxalate monohydrate (COM) and mixed stones having minor existence of struvite and uric acid. Hexagonal shaped COM crystals, needle shaped uric acid crystals and layered arrangement of struvite crystals in the core region were revealed by Scanning Electron Microscopy (SEM). Thermo Gravimetric Analysis (TGA) was used to determine the thermal stability and the hardness of the stone which was measured using Vickers hardness (HV). The presence of toxic elements in stones such as zirconium and mercury was identified using Energy Dispersive X-ray Spectroscopy (EDS). The EDS analysis showed higher concentration of zirconium in the core region compared to the periphery. The percentage of zirconium was relatively high compared to other toxic elements in the stones. The Vickers hardness results indicated that high HV values in the core region than the periphery and this might be due to the presence of zirconium.

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### Introduction

Urinary stones are formed in the kidneys due to the various environmental aspects and are affecting 20% of the population [1]. Further, the recurrence rate is up to 50% [2]. It is influenced by many factors such as age, sex, occupation, diet, fluid intake,

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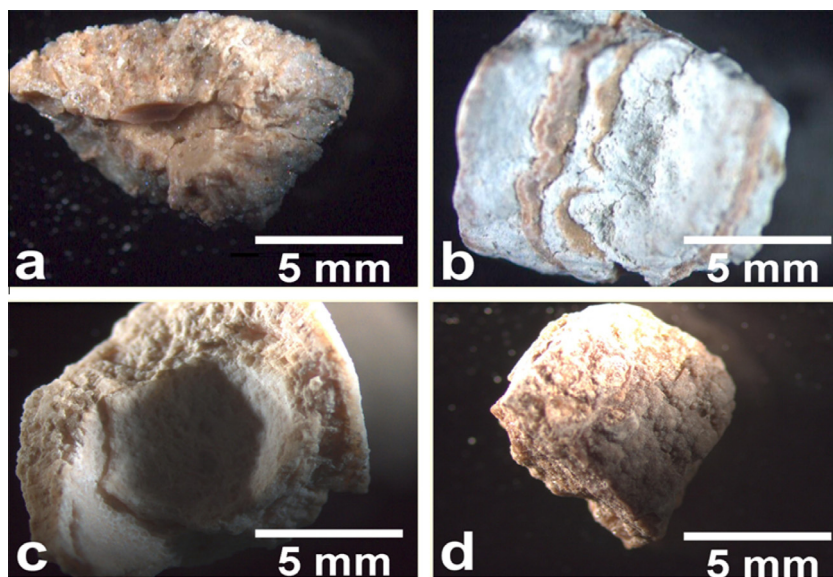


Fig. 1. (a) COM, (b) uric acid, (c) struvite and (d) mixed stone.

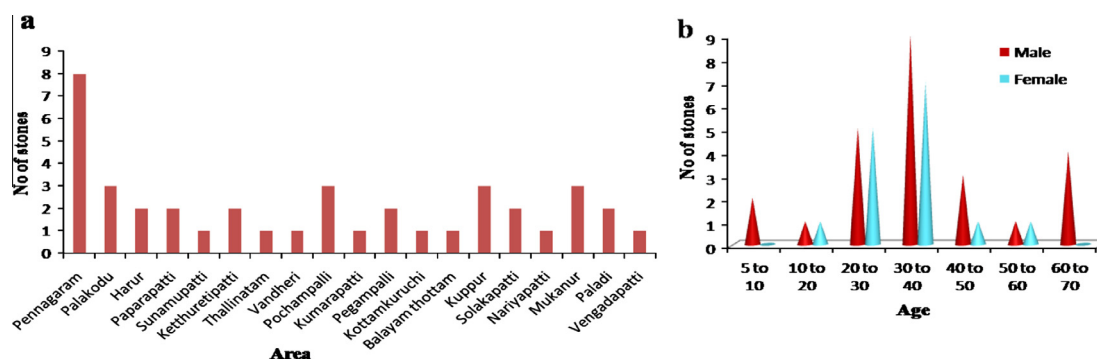


Fig. 2. (a) Correlation of number of stones collected at different areas in the Dharmapuri district and (b) correlation of nephrolithiasis with respect to the sex of various age groups.

water quality, geographical location and climate [3,4]. Calcium oxalate ( $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$  (COM),  $\text{CaC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$  (COD), struvite ( $\text{MgNH}_4\text{-PO}_4 \cdot \text{H}_2\text{O}$ ), uric acid ( $\text{C}_5\text{N}_4\text{O}_3\text{H}_4$ ), xanthine ( $\text{C}_5\text{H}_4\text{N}_4\text{O}_2$ ) and cystine [ $-\text{S}-\text{CH}_2-\text{CH}-(\text{NH}_2)-\text{COOH}]_2$  are the basic compounds constituting the urinary stone. About 75% of urinary stones are calcium oxalate based [5,6] and in some cases they are mixed stones. The toxic minerals present in the ground water play a significant role in the urinary stone formation. The concentration of these toxic minerals in the groundwater is based on soil acidity, rock acidity, temperature, chemical and physical characteristics of the aquifer in that geological location which may lead to the formation of stones in the kidneys of human body [7,8]. Excess amount of toxic minerals in the groundwater has drawn worldwide attention due to their considerable impact on human health. Moreover, their presence has been identified in urinary stones and gallstones [9]. Dharmapuri, Salem and Vellore districts located in Tamil Nadu are having the high concentration of the toxic minerals in the groundwater. These toxic elements were causing dental and skeletal fluorosis in the human body [10]. The high concentration of these toxic mineral in the soil could be due to the erosion of rocks. Dharmapuri district located in the northern part of Tamil Nadu in the southern India, was chosen for the study due to the high occurrence of urinary stones among their human population. Carbonatite is a unique types of rock which is prevalent in this region. These rocks contain the high concentration of radioactive elements and anomalous concentration of iron, zirconium, fluorine and also rare earth

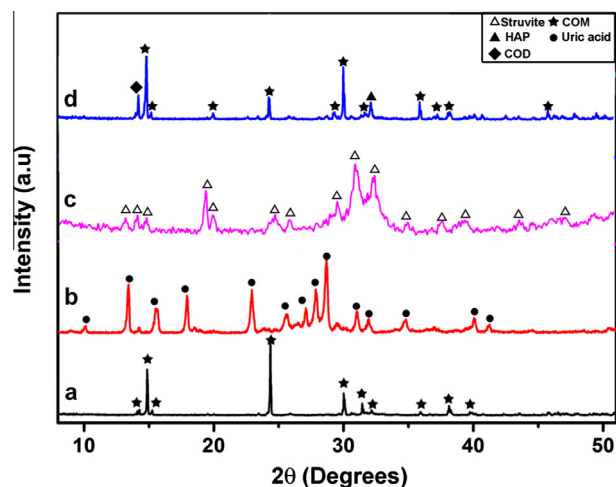


Fig. 3. XRD pattern of (a) COM, (b) uric acid, (c) struvite and (d) mixed stone.

elements [11–15]. These elements contaminate the soil and the water sources which lead to the various diseases in human beings. In the present study, the structural, spectroscopy and morphology were investigated besides, thermal and mechanical studies were also carried out on the urinary stones.

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