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# Detection of Heavy Toxic Metals in Some Common Ayurvedic Preparations Using Energy Dispersive X-Ray Fluorescence (EDXRF) Spectrophotometry.

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ABSTRACT

Ayurvedic medicines are a part of Indian cultural and tradition. These medicines are taken by many people for treatment of different ailments. Different types of metallic compounds are used in the preparation of ayurvedic medicines. Consumption of ayurvedic medicines for a long period might result in chronic heavy metal poisoning. In the wake of such cases it becomes important to maintain the concentration of metals in such medicines. In this paper an attempt has been made to determine the presence of heavy metals in some commonly available ayurvedic medicines using energy dispersive X-ray fluorescence (EDXRF) spectrophotometry. 21 samples of different ayurvedic medicines were analyzed for the presence of arsenic (As), mercury (Hg), and lead (Pb).

**Keywords:** Herbal preparations, ayurvedic medicines, heavy toxic metals, X-ray fluorescene spectrophotometry

## Introduction

Ayurveda is science or knowledge of life of human beings. It is a traditional system of medicine in India and known to be practiced even before 4000 B.C. Kastha ausadhis (prepared from herbal products), Rasa ausadhis (metallic preparations) and Jangama ausadhis (prepared from animal products) are three different kinds of ayurvedic preparations [1, 2]. It has been estimated that about 80% Indian population uses ayurvedic preparations and their use in western countries is also

increasing these days [3]. Approximately, 28% and 59% population use complementary and alternative medicines in UK and USA respectively. In Canada, 42% patients of oncology and 70% of juvenile chronic arthritis and 72% patients of inflammatory bowel disease use complementary and alternative medicines. Increasing use of ayurvedic drugs is due to the belief that natural products are safe thus free from side effects and their less cost in comparison to allopathic medicines [4]. In a survey conducted by Arya and his coauthors in 2012 at Joginder Nagar (a region of Himachal Pradesh, India), it was found that 64.8% people preferred ayurvedic medicines whereas 32.6%, 1.8% and 0.8% population preferred allopathic, homeopathic and unani medicines respectively. 73.2% consumers take ayurvedic medicines without the prescription of doctor. Ayurvedic medicines along with allopathic and homeopathic medicines are taken by 37.2% consumers for treatment of prevalent diseases [5].

Heavy metals are integral component of ayurvedic preparations. Depending on their role in biological system, these can be essential or non-essential heavy metals. Essential heavy metals such as copper, cobalt, iron, magnesium, nickel, zinc etc., play significant role in various biochemical and physiological processes in plants and animals and are constituents of different enzymes. Excess or deficiency of these metals in body can causes cellular and tissue damage. Non-essential heavy metals such as aluminum, antimony, arsenic, barium, bismuth, cadmium, lead, mercury etc., play no role in any biochemical process [6].

Heavy metals are considered as toxic in nature. These enter body system through various pathways, like through food chain, drinking water contaminants, high ambient air concentration, soil, medications, occupational exposures etc. On entering living system, they tend to accumulate in body as they are taken up and stored faster than their metabolism or excretion. In living system, metal ions affect cellular organelles and components (cell membrane, mitochondria, lysosome, endoplasmic reticulum, nuclei) and enzymes which are important for different processes like metabolism, detoxification and damage repair. These also interact with cell components such as DNA and nuclear proteins and lead to DNA damage and other changes like cell cycle modulation, carcinogenesis or apoptosis [6]. Commons symptoms of toxicity due to heavy metals like arsenic, mercury, and lead are vomiting, diarrhoea, cramps, paralysis, malaise, restlessness, nausea, weakness. Arsenic, cadmium, chromium, lead and mercury are known as system toxicants because they cause multiple organ damage even at lower levels of exposure and are considered as heavy toxic metals.

Bhasma, parpati, rasayoga and sindoora are some common kinds of ayurvedic preparations containing heavy toxic metals. Bhasma is anything organic or inorganic burnt into its ash. Bhasmas are of different types based on dominating metal and mineral group (Naag Bhasma, Loha Bhasma, Rajata Bhasma, Tamra Bhasma etc.) [2]. Parpati preparations are made from purified mercury and sulfur [1]. Rasayoga preparations contain mercury and sulphur along with other metals or minerals. Ras Sindoora is prepared by sublimation of minerals and sublimed mineral present on neck of sublimation glass flask is Sindoora [2].

Out of these four types of ayurvedic preparations, Bhasmas are most commonly prescribed and used for treatment of diseases [7]. It is believed that mercury and lead which are widely used in traditional medicine system act as catalyst because they stimulate catalytic activity by their presence in intestine. It is also believed that toxic effects of these medicines are neutralized by honey, ghee or milk which is taken orally as medium along with these types of preparations [8].

Analysis of different ayurvedic formulations showed the presence of different heavy metal content even at higher levels from their permissible values. Ayurvedic preparations analyzed in present study are used for different ailments. For example, Yograj guggulu is taken for rheumatism gout, muscular pain etc. Karela is taken for its metabolism- regulating properties. Mahayograj Guggulu is useful in all types of vataj disorders. Maha Sudarshan churna is useful for treatment of fever and Triphala churna helps to relieve from constipation. It also improves digestion as well as beneficial for eyes. Nimbadi churna is useful in fungal and other types of skin infections. In case of cough, hyperacidity, hemorrhage and calcium deficiency, prawal pishti is effective. Madohar gugloo is taken to reduce obesity. Stri Rasayan vati is useful in gynecological problems such as metrorrhagia, menorrhagia, leucorrhoea etc. Calm - HI is useful in depression and helps in controlling blood pressure. Number of cases has been reported in which death has occurred due to toxicity from heavy metals by consuming ayurvedic preparations [9-11].

## Materials and method

### Collection of samples

*Standard Samples:* Standard samples of arsenic (arsenic trioxide, $As_2O_3$), mercury (mercury chloride, $Hg_2Cl_2$) and lead in metallic form were taken from Nuclear Science Laboratories, Physics Department, Punjabi University, Patiala.

*Ayurvedic Preparations:* 21 samples of ayurvedic preparations were collected from local market of Delhi and Hoshiarpur (a district of Punjab). All samples were of different brands. Description of samples analyzed in the present study is given in table no. 1.

***Preparation of samples:*** Tablets were crushed and homogenized with help of pestle mortar and fine powder was obtained. Covers of capsules were removed and powder was used for the analysis. Powdered samples were collected in small clean transparent polythene bags and kept as such under normal laboratory conditions till their analysis.

***Analysis of samples:*** All standards and ayurvedic preparations were analyzed using Energy Dispersive X-ray Fluorescence (ED-XRF) spectrophotometry. All samples were analyzed at Nuclear Science Laboratories, Physics Department, Punjabi University, Patiala. Transparent bags containing powdered samples were placed on sample holder with the help of cellotape and then were placed in front of X-ray tube photon source. X-ray tube source comprises a low power Neptune X-ray tube (Oxford instruments, USA) with Coolidge based Rhodium target as anode and 2mA/50kV maximum filament current/ anode voltage. There was 100W regulated high voltage direct current (HVDC) power supply and a water cooling system. Amptek- X123 spectrometer with Si-PIN detector having 0.5mil beryllium window and of dimensions $6mm^2$/500µm with energy resolution 145eV at 5.959keV Mn K X-rays. Spectra were recorded with software Microsoft (TM) origin® having 6.0 version. Spectra were stored in personal computer for further offline analysis. 16keV voltage was applied for samples as well as standards. Spectrum of transparent bag was also recorded as a control prior to sample analysis. Spectra of all ayurvedic preparation samples were recorded for time period of 500 seconds whereas for standards, spectra were recorded for 200 seconds as this time period was sufficient for obtaining the spectra of pure samples whereas in ayurvedic preparation samples, there are different components present so exposure time was more than standard samples. Thus, exposure time for recording spectra of standard samples and ayurvedic preparations was different.

## Results and Discussion

In present study, 21 samples of ayurvedic preparations were analyzed using Energy Dispersive X-ray Fluorescence (EDXRF) spectrophotometry for the detection of heavy toxic metals. Peaks obtained at different energies were compared with Photon cross sections from 1 keV to 100MeV for elements Z= 1 to Z= 100* (Ellery Storm and Harvey I. Israel). Figure 1 shows the EDXRF spectrum of standard arsenic trioxide ($As_2O_3$). Spectrum shows the characteristic peaks at energy values 10.5 and 11.7 keV due to As (Kα) and As (Kβ) respectively. Peak due to Fe (Kα) was observed at 6.3 keV. Figure 2 shows the EDXRF spectrum of standard mercury chloride ($Hg_2Cl_2$). Spectrum shows the characteristic peaks at energy values 8.7, 9.9 and 11.9 keV due to Hg (Le), Hg (Lα) and Hg (Lβ) respectively. At energy value 6.3 keV, a peak was observed due to Fe (Kα). Figure 3 shows the EDXRF spectrum of standard metallic lead. Spectrum shows the characteristic peaks at energy values 9.1, 10.5 and 12.6 keV due to Pb (Le), Pb (Lα) and Pb (Lβ) respectively. Peak due to Fe (Kα) was observed at 6.3 keV.

In EDXRF spectrum (Figure 4) of Yograj Guggulu, characteristic peaks at energy values 3.7, 4.0, 4.6, 6.4 and 7.1 keV due to Ca (Kα), Sc (Kα), Ti (Kα), Fe (Kβ) and Fe (Ke) were observed. In present study, not even a single heavy toxic metal was detected in Yograj Guggulu. However, 9.766µg/g and 8.233µg/g of mercury was detected in Yograj using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) and hydra-C direct mercury analyzer [12]. EDXRF spectrum (Figure 5) of Karela shows characteristic peaks at energy values 3.6, 4.0, 4.5, 4.9, 6.4, 7.0, 8.1 and 8.9 keV due to Ca (Kα), Sc (Kα), Ti (Kα), V (Kα), Fe (Kβ), Fe (Kβ), Cu (Kα) and Cu (Kβ). Lead was detected in Karela using X-ray fluorescence spectrophotometry [13].

EDXRF spectrum (Figure 6) of Mahayograj Guggulu shows characteristic peaks at energy values 6.4, 7.1, 8.7, 10.0, 10.5, 11.9 and 12.6 keV due to Fe (Kβ), Fe (Ke), Hg (Le), Hg (Lα), Pb (Lα), Hg (Lβ) and Pb (Lβ) respectively. It was observed that peaks at 8.7, 10.0, 10.5, 11.9 and 12.6 keV shows the presence of mercury (Hg) and lead (Pb) in Mahayograj Guggulu. High concentration of mercury and lead was also found in Mahayograj Gugloo using Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) [14]. EDXRF spectrum (Figure 7) of Maha Sudarshna Churna shows the characteristic peaks at 3.7 keV (due to Kα line series of Ca), 4.0 keV (due to Kα line series of Sc), 4.5 keV (due to Kα line series of Ti), 5.9 keV (due to Kβ series of Cr), 6.4 keV (due to Kβ series of Fe) and 7.1 keV (due to Ke of Fe) which indicates the presence of Ca, Sc, Ti, Cr and Fe in sample. In a similar study, lead was detected in two samples of Maha Sudarshan churna, made from different manufacturers, using X-ray Fluorescence (XRF) spectrophotometry [13]. In another study, 10.644µg/g and 9.519µg/g of mercury was detected in Mahasudarshan using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) and hydra-C direct mercury analyzer (12). However, in present study, no such heavy toxic metal was detected in Mahasudarshan.

Figure 8 presents the EDXRF spectrum of Triphla Churna. Spectrum shows the characteristic peaks at energy values 3.7, 4.1, 4.5, 6.4 and 7.1 keV due to presence of Ca (Kα), Sc (Kα), Ti (Kα), Fe (Kβ) and Fe (Ke) respectively in sample. In another study, Ca, Cu, Mg, Zn and Al along with trace amounts of As, Hg, Cd and Pb was detected in two samples of triphala using atomic absorption spectrophotometry(AAS) (15). In a different study, 0.002µg/g and 0.188µg/g of mercury was detected in two samples of triphala using hydra-C direct mercury analyzer and 0.182µg/g and 0.005µg/g of mercury was detected in two samples of triphala using ICP-MS [12]. However, in present study, no such heavy toxic metal was detected in samples of triphala.

Figure 9 shows the EDXRF spectrum of Nambadi Churma. Spectrum shows the characteristic peaks at energy values 3.6 keV (due to Kα line series of Ca), 3.9 keV (due to Kα line series of Sc), 4.4 keV (due to Kβ line series of Sc), 6.3 keV (due to Kα line series of Fe) and 6.9 keV (due to Kα line series of Co) shows the presence of Ca, Sc, Fe and Co in Nambadi Churma. Using AAS, Ca, Cu, Mg, Zn, Al along with As, Cd, Hg and Pb in trace amounts were detected [15]. Figure 10 shows the EDXRF spectrum of Prawal Pishti. Spectrum shows the characteristic peaks at energy values 3.7 keV (due to Kα line series of Ca), 4.0 keV (due to Kα line series of Sc) and 6.4 keV (due to Kβ line series of Fe) shows the presence of Ca, Sc and Fe in sample. Different amounts of Al, As, Au, Br, Ca, Cl, Co, Cu, Fe, Hg, K, La, Mg, Mn, Nu, P, V and Zn were detected in Praval Pishti by using NAA [8]. Figure 11 shows the EDXRF spectrum of Madohar Gugloo. Spectrum shows the characteristic peaks at energy values 3.6, 3.9, 4.3, 5.8, 6.3 and 6.9 keV due to Ca (Kα), Sc (Kα), Sc (Kβ), Mn (Kα), Fe (Kα) and Co (Kβ). Figure 12 shows the EDXRF spectrum of Parwatni vati. EDXRF spectrum shows the characteristic peaks at energy values 6.3 keV (due to Kα line series of Fe) and 6.9 keV (due to Kβ line series of Co) shows the presence of Fe and Co in the Parwatni vati.

Figure 13 shows the EDXRF spectrum of Stri Rasayan vati. EDXRF spectrum shows the characteristic peaks at energy values 6.2 keV (due to Kα series of Fe) and 6.9 keV (due to Kβ series of Co) shows the presence of Fe and Co in sample. Figure 14 shows EDXRF spectrum of Calm-HI. Spectrum shows the characteristic peaks at energy values 3.9, 4.3, 4.8, 6.2 and 6.9 keV due to Sc (Kα), Sc (Kβ), Ti (Kα), Fe (Kα) and Co (Kβ). Figure 15 shows the EDXRF spectrum of Ras Parpati. Spectrum shows the characteristic peaks at energy values 6.2 keV (due to Kα line series of Fe), 8.5 keV (due to Le of Hg) and 9.9 keV (due to Lα line series of Hg). Peaks at energy 10.4 and 11.7 keV due to As (Kα) and As (Kβ) in sample. Thus, peaks at different energy values shows the presence of As and Hg in Ras Parpati. Al, As, Ca, Fe, Hg, K, Mg, Mn, Na, Si, Zn were found in two samples of Rasa Parpati by using ICP- OES and Pb and Cd by using GF- AAS. Figure 16 shows the EDXRF spectrum of Panchamrit Parpati. Spectrum shows the characteristic peaks at 5.2, 5.8, 6.3, 6.8, 7.9 keV due to Cr (Kα), Mn (Kα), Fe (Kα), Co (Kα), Cu (Kα) respectively. Characteristic peaks at 9.8 and 11.7 keV were due to Lα series of Hg and Kβ series of As. Thus, peaks at 9.8 and 11.7 keV shows the presence of As and Hg in Panchamrit Parpati. Al, As, Ca, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Si and Zn were detected by using ICP-OES and Cd and Pb were detected by using GF- AAS [16].

Figure 17 shows the EDXRF spectrum of Mahayograj Gugloo. Spectrum shows the characteristic peaks at 6.2 and 6.9 keV due to Fe (Kα) and Co (Kα) respectively. Another sample of Mahayograj gugloo (manufacturer Baidyanath, Jhansi, sample no. 6 shows the presence of Hg and Pb along with Fe. Literature also reveals the presence of these heavy metals in Mahayograj Gugloo [14]. In present study, no detection of heavy metals in sample may be due to two reasons. Firstly, there may be no heavy metal in sample and secondly, heavy metals may be present in very trace amounts and cannot be detected by EDXRF. Figure 18 shows the EDXRF spectrum of Kaishor Gugloo. Spectrum shows the characteristic peaks at energy values 6.3, 6.9 keV due to Fe (Kα), Co (Kβ) and characteristic peak at 8.4 keV due to Ni (Ke) and Zn (Kα). Ba, Cr, Mn, Ni, Ca, Mg, Na along with Sn, Al, Fe, P, Si in very low amounts were detected by ICP- OES [14]. Figure 19 shows the EDXRF spectrum of Chandraprabha Vati. Spectrum shows the characteristic peaks at 6.2 and 6.8 keV due to Fe (Kα) and Co (Kα). Ba, Cr, Mn, Ni, Ca, Mg, Na with trace amounts of As, Cu, Pb, Sn, Al, Fe, K, P, Si were detected using ICP- OES [14]. Figure 20 shows the EDXRF spectrum of Chandraprabha Vati. Spectrum shows the characteristic peaks at 4.3, 4.7, 6.2 and 6.9 keV due to Sc (Kβ), Ti (Kβ), Fe (Kα) and Co (Kα) respectively. Ba, Cr, Mn, Ni, Ca, Mg, Na with trace amounts of As, Cu, Pb, Sn, Al, Fe, K, P, Si were detected using ICP- OES [14].

Figure 21 shows the EDXRF spectrum of Naag Bhasma. Spectrum shows the characteristic peaks at 4.0, 4.4, 6.3, 7.0 keV due to Sc (Kα), Sc (Kβ), Fe (Kα), Fe (Kβ) respectively. Characteristic peaks at 9.1 keV (due to Le of Pb), 10.6 keV (due to Lα line series of Pb) and 12.6 keV (due to Lβ line series of Pb) shows the presence of Pb. 3 samples of Naag Bhasma from different batches by different techniques like thermogravimetric analysis, FTIR, Particle Size Analyzer, surface area analyzer, XRF, SEM with EDXRF and XRD. EDXRF analysis showed presence of both arsenic and lead (Nagarajan et al, 2012). Figure 22 shows the EDXRF spectrum of Kushta qali. Spectrum shows the characteristic peaks at 3.6, 6.3, 8.6 and 9.6 keV due to Ca (Kα), Fe (Kα), Zn (Kβ) and Ge (Kα) respectively. Using AAS, high concentration of Pb was found in Kushta qali [17]. Figure 23 shows the EDXRF spectrum of Rasamanikya. Spectrum shows the characteristic peaks at 6.4 keV due to Fe (Kβ). Characteristic peaks at 10.5 and 11.7 keV due to Kα line series of As and Kβ line series of As, shows the presence of As in the sample. As and Pb along with S, Cd, Mn, Co, Cr, Ni was analyzed in Rasamanikya [18]. Figure 24 shows the EDXRF spectrum of Triguliv. Spectrum shows the characteristic peaks at 3.6, 4.5, 4.9, 6.3, 7.0 and 8.0 keV due to Ca (Kα), Ti (Kα), Ti (Kβ), Fe (Kα), Fe (Kβ) and Cu (Kα) respectively. Peak at 6.2, 6.3 and 6.4 keV is observed in all samples and it is due to instrumental interference.

## Conclusion

Ayurveda is a well-established system of medicine in India and its popularity is also increasing among other countries. Less side effects and cost effectiveness are major reasons behind their use over allopathic medicines. As ayurveda pharmaceutical industry is growing on, there is an increasing need to audit the quality of ayurvedic preparations. It is concluded that energy dispersive X-ray fluorescence (EDXRF) spectrophotometry is an effective, rapid and useful technique for the detection of heavy toxic metals in ayurvedic preparations in a non-destructive manner without extensive sample preparation.

## Conflict of Interest

None to Declare.

**Table 1- Description of samples (standards and ayurvedic preparations) analyzed in the present study**

| S. No | Sample Name | Form | Color | Manufacturer |
|---|---|---|---|---|
| 1. | Arsenic | Powder | White | - |
| 2. | Mercury | Powder | White | - |
| 3. | Lead | Powder | Greyish | - |
| 4. | Yograj Guggulu | Tablet | Light Brownish | Baidyanath, Jhansi |
| 5. | Karela | Capsule | Dark Green | Himalaya, Bangalore |
| 6. | Mahayograj Guggulu | Tablet | Brownish | Baidyanath, Jhansi |
| 7. | Maha Sudarshan Churna | Powder | Light Brownish | Baidyanath, Jhansi |
| 8. | Triphala churna | Powder | Light Brownish | Dabur, Alwar (Rajasthan) |
| 9. | Nimbadi Churna | Powder | Light Brownish | Vyas Pharmaceuticals, Indore |
| 10. | Prawal Pishti | Powder | Light Peach | Baidyanath, Jhansi |
| 11. | Madohar Gugloo | Tablet | Blackish | Parkirtak Ayurvedic Aushdaliya, Kurukshetra |
| 12. | Parwatni Vati | Tablet | Blackish | Parkirtak Ayurvedic Aushdaliya, Kurukshetra |
| 13. | Stri Rasayan Vati | Tablet | Dark Brown | Divya Pharmacy, Haridwar |
| 14. | Calm- HI | Tablet | Peach | H. Dhari Shah Pharmacy, Ambala Cantt |
| 15. | Ras Parpati | Flakes | Black | D.A.V. Pharmacy, Jalandhar |
| 16. | Panchamrit Parpati | Flakes | Black | D.A.V. Pharmacy, Jalandhar |
| 17. | Mahayograj Guggulu | Tablet | Brown | D.A.V. Pharmacy, Jalandhar |
| 18. | Kaishor Gugloo | Tablet | Black | D.A.V. Pharmacy, Jalandhar |
| 19. | Chandraprabha | Tablet | Brown | D.A.V. Pharmacy, Jalandhar |
| 20. | Chandraprabha | Tablet | Yellowish Orange | D.A.V. Pharmacy, Jalandhar |
| 21. | Naag Bhasma | Powder | Cream | D.A.V. Pharmacy, Jalandhar |
| 22. | Kushta Kali | Powder | White | D.A.V. Pharmacy, Jalandhar |
| 23. | Rasamanikya | Flakes | Brownish | D.A.V. Pharmacy , Jalandhar |
| 24. | Triguliv | Tablet | Pink | Trimula Ayurvedic Pharmacy |

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## What's New in This paper

### What is already known on this subject

Various techniques such as AAS and ICP-MS have been used for the detection of heavy toxic metals in different samples of Ayurvedic preparations.

### What this study adds

No previously reported work was found on the samples used in the present study. EDXRF, a sensitive technique was used for the analysis of the different Ayurvedic preparations to determine presence of metals quantitatively.

### Suggestions for further development

More studies must be done on other Ayurvedic preparations using sensitive techniques such as EDXRF, ICP-MS, AAS, etc.

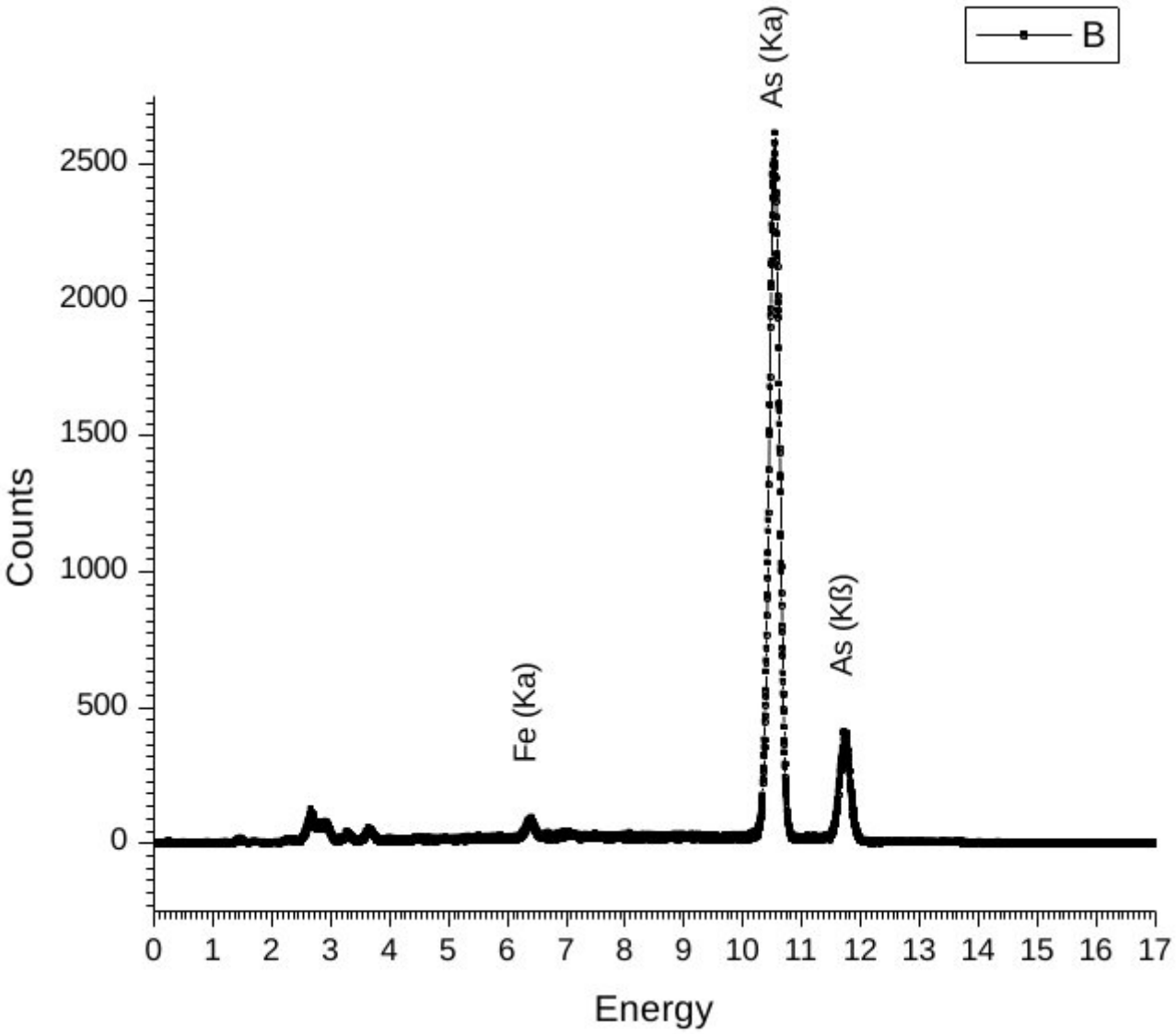


Fig. 1- EDXRF spectrum of Arsenic trioxide ($As_2O_3$) (sample 1)

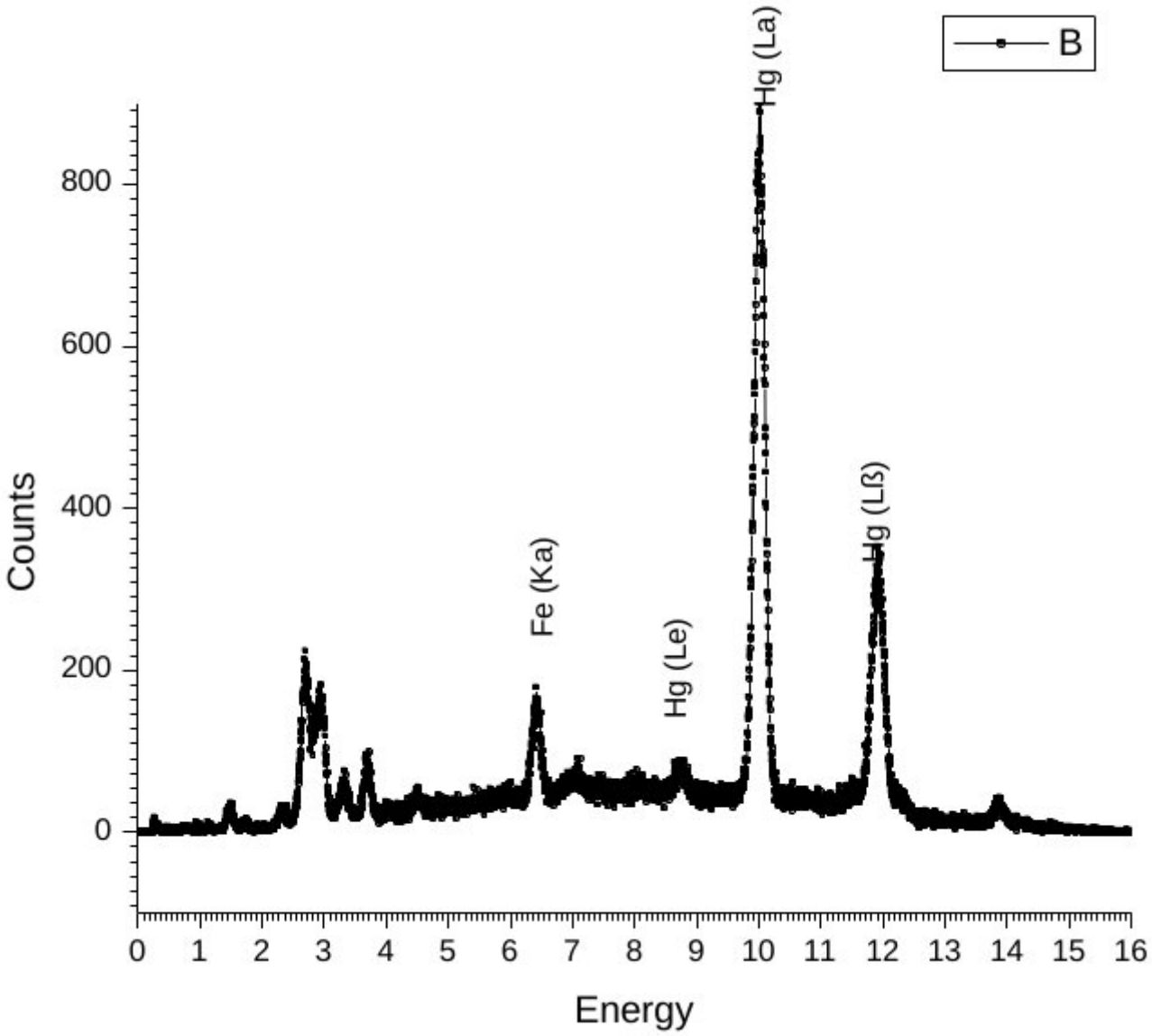


Fig. 2- EDXRF spectrum of Mercury chloride ($Hg_2$ $Cl_2$) (sample 2)

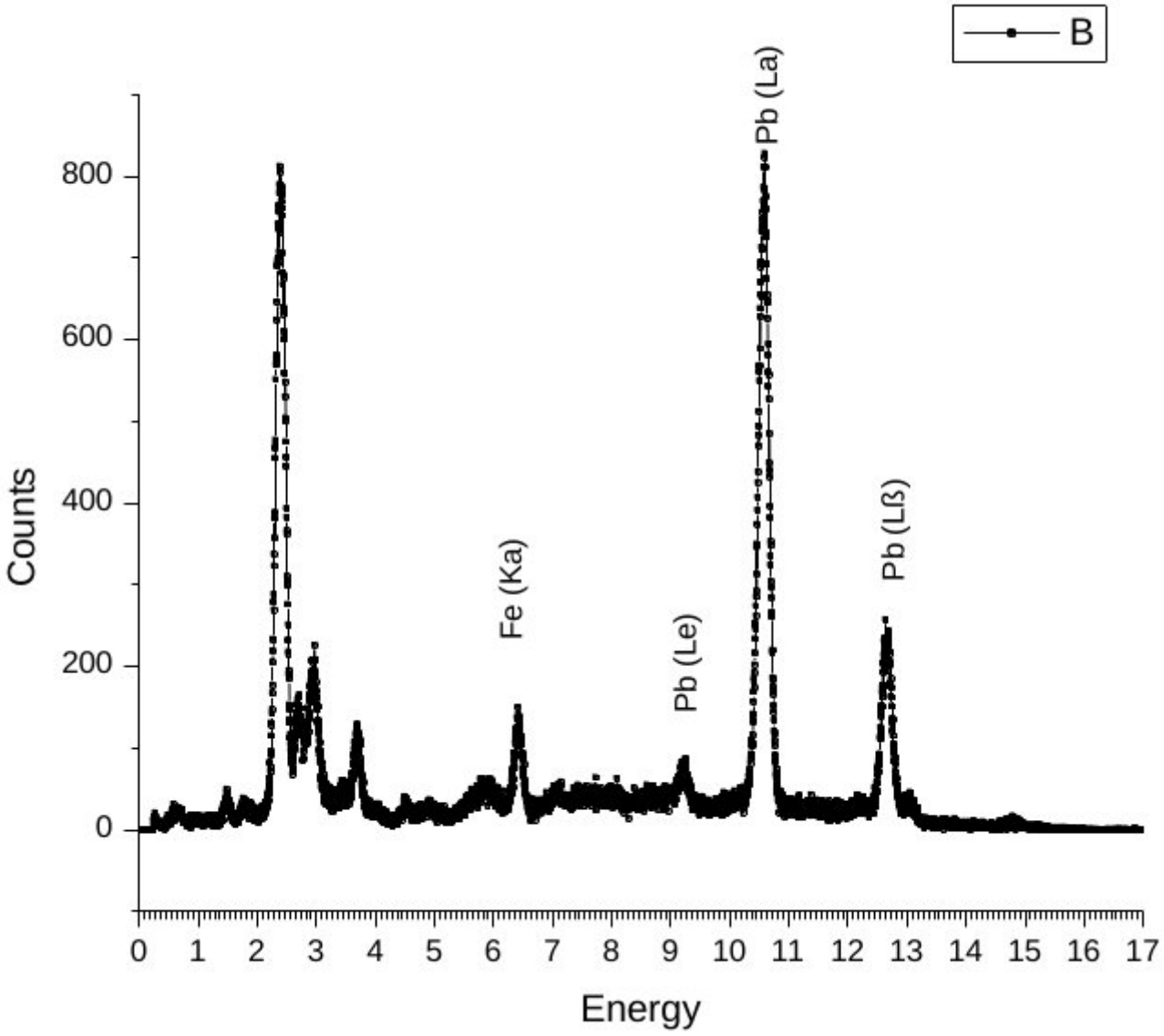


Fig. 3- EDXRF spectrum of metallic Lead (sample 3)

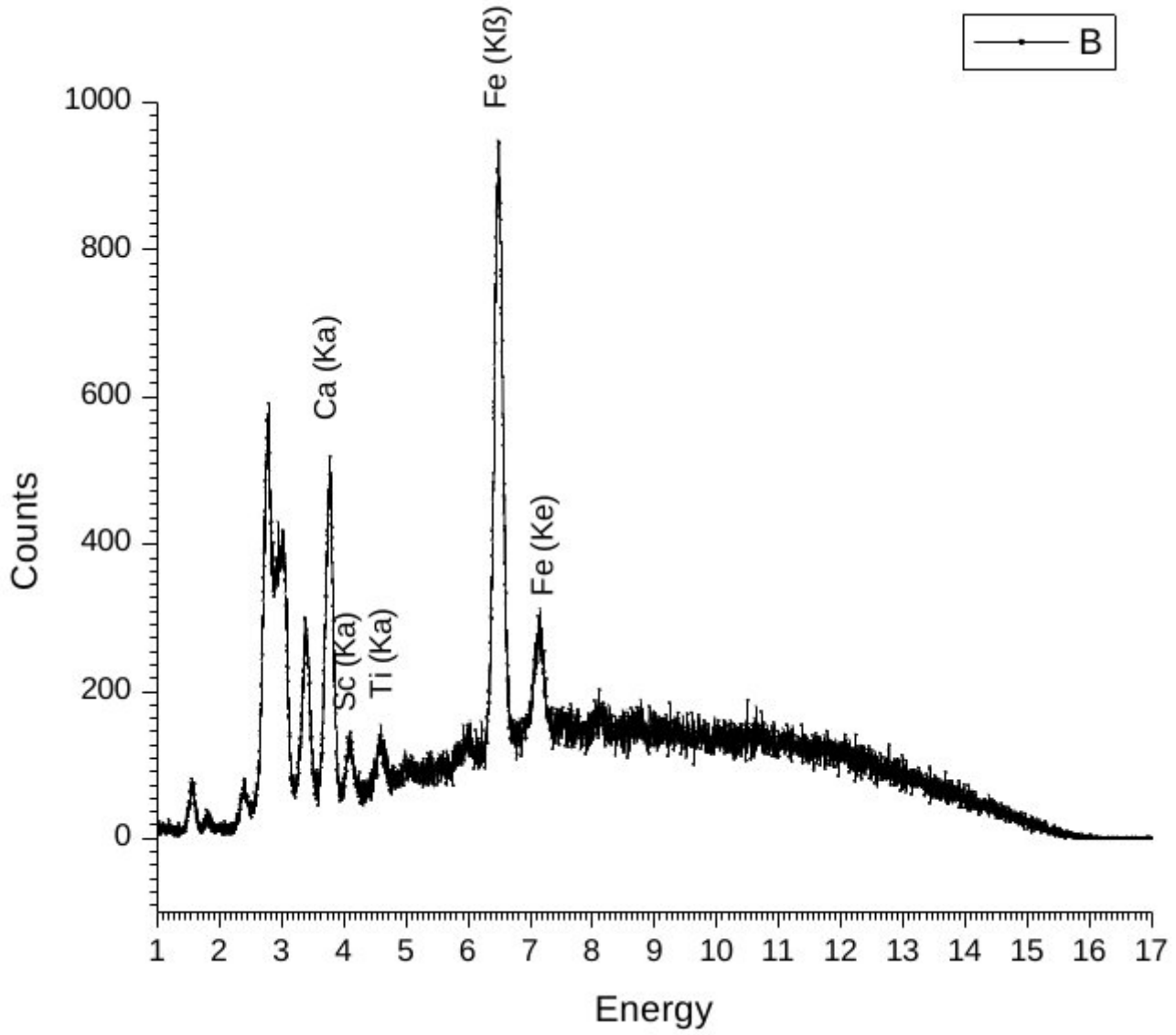


Fig no. 4- EDXRF spectrum of Yograj guggulu (sample 4)

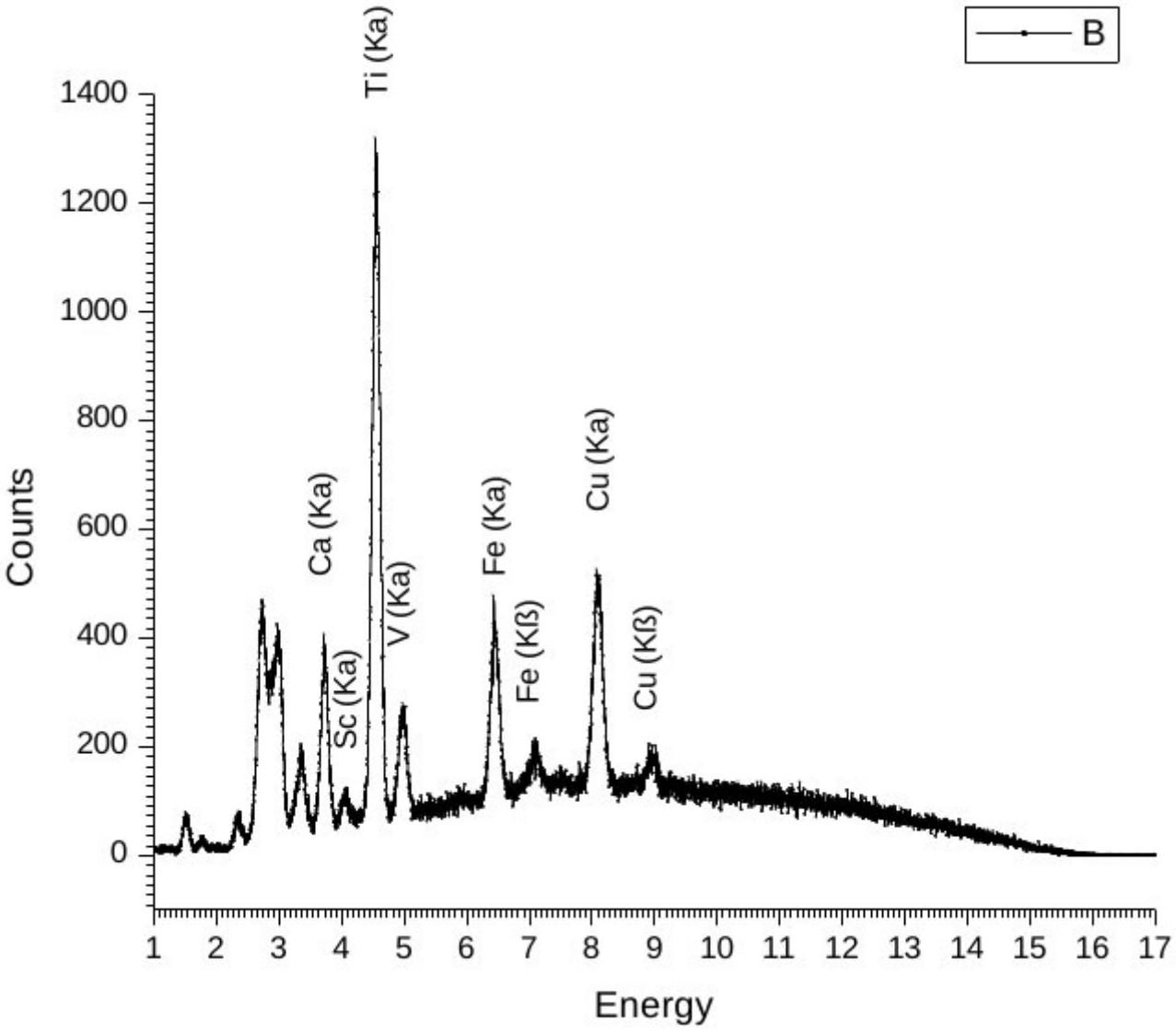


Fig 5- EDXRF spectrum of Karela (Sample no. 5)

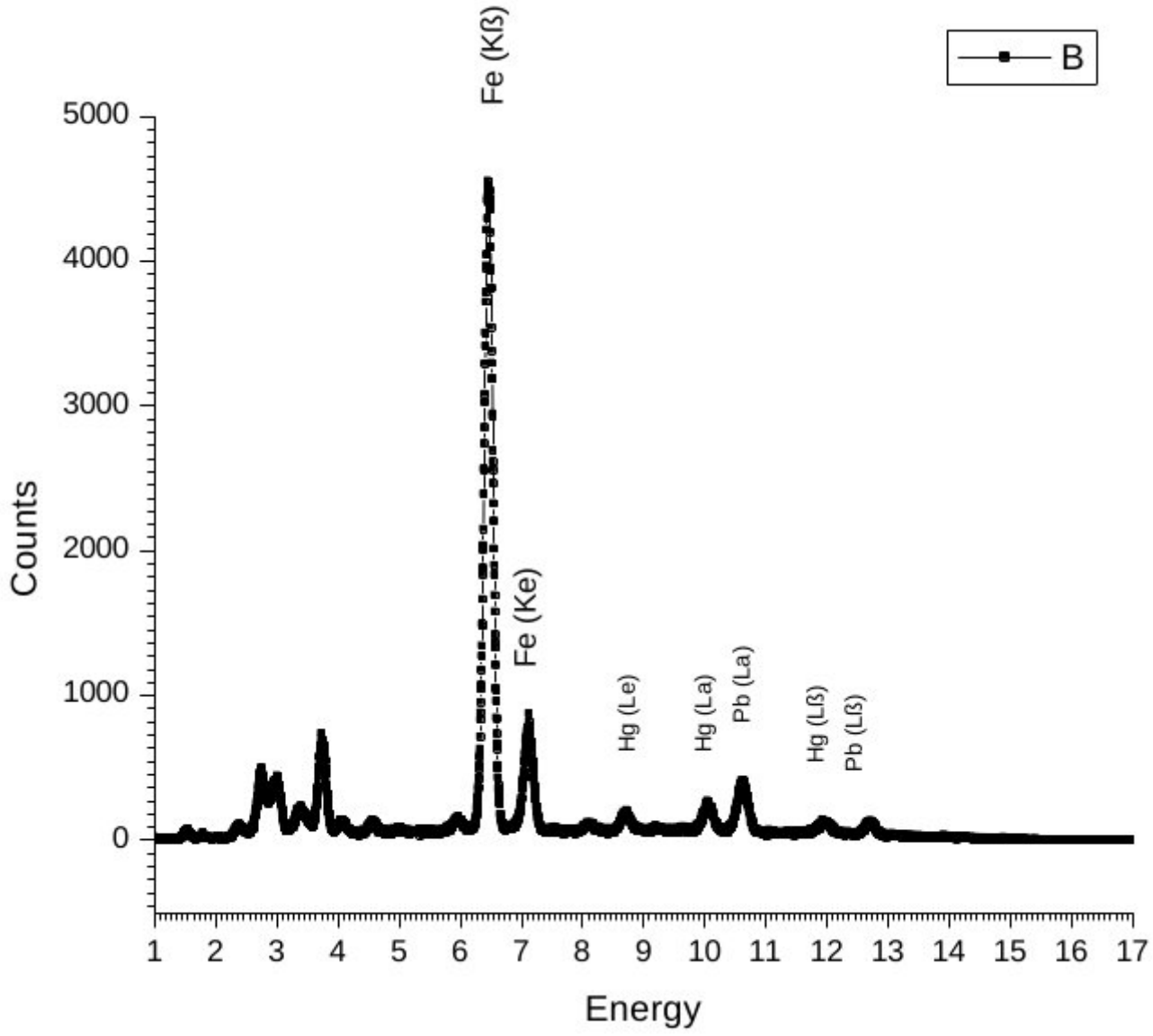


Fig 6- EDXRF spectrum of Mahayograj Guggulu (Sample no. 6)

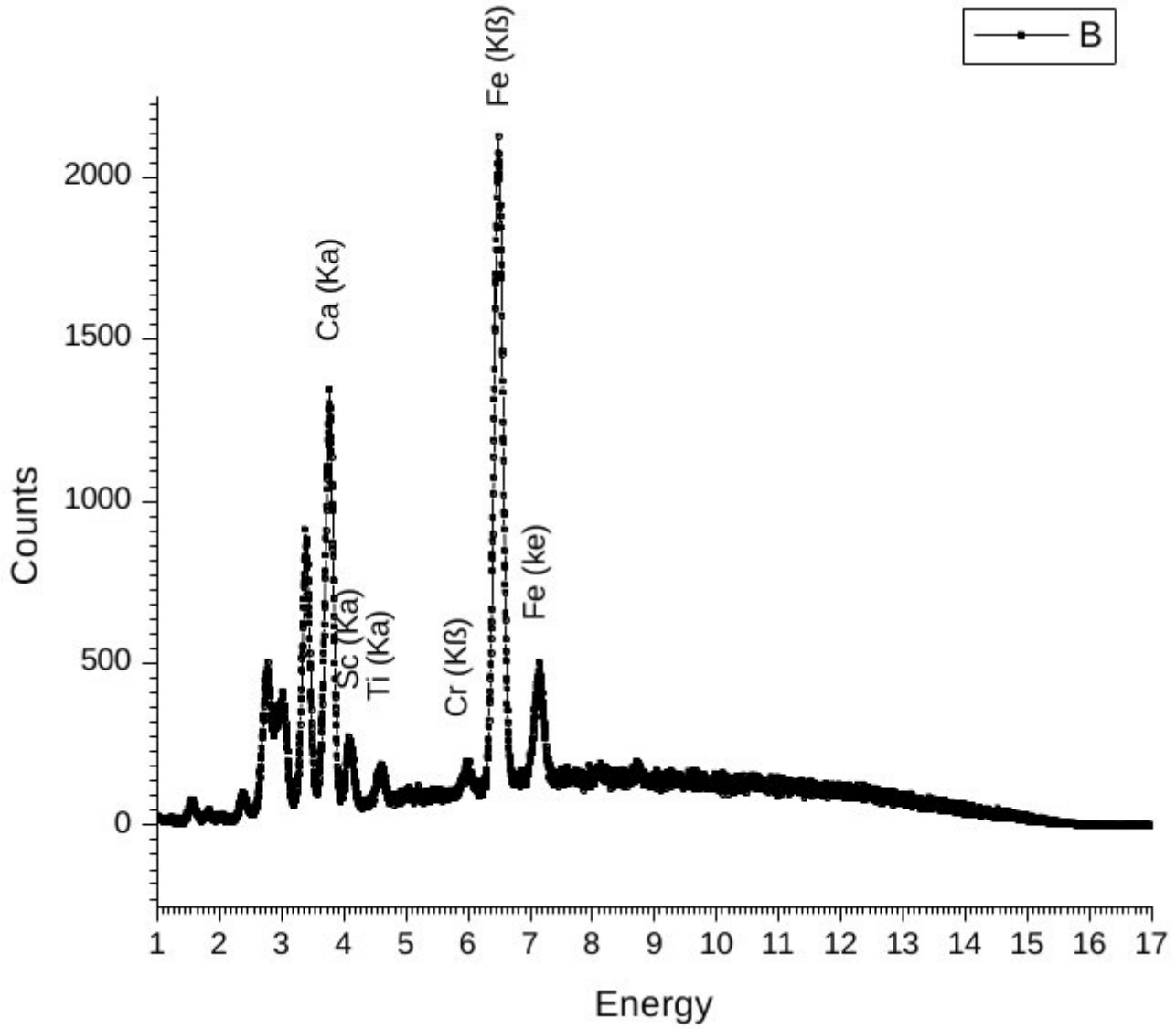


Fig 7- EDXRF spectrum of Maha- Sudarshna Churma (Sample no. 7)

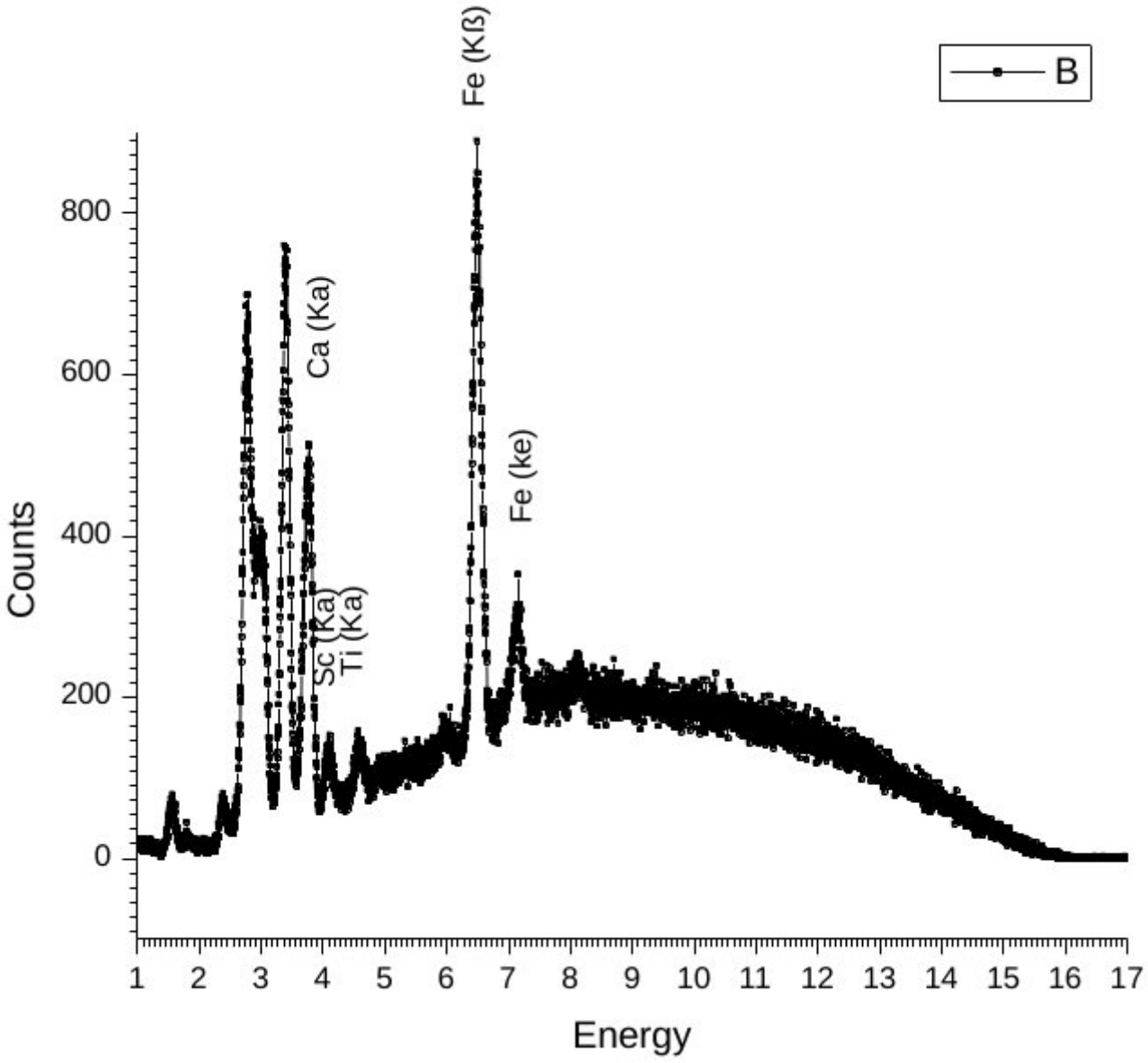


Fig 8- EDXRF Spectrum of Triphla Churma (Sample no. 8)

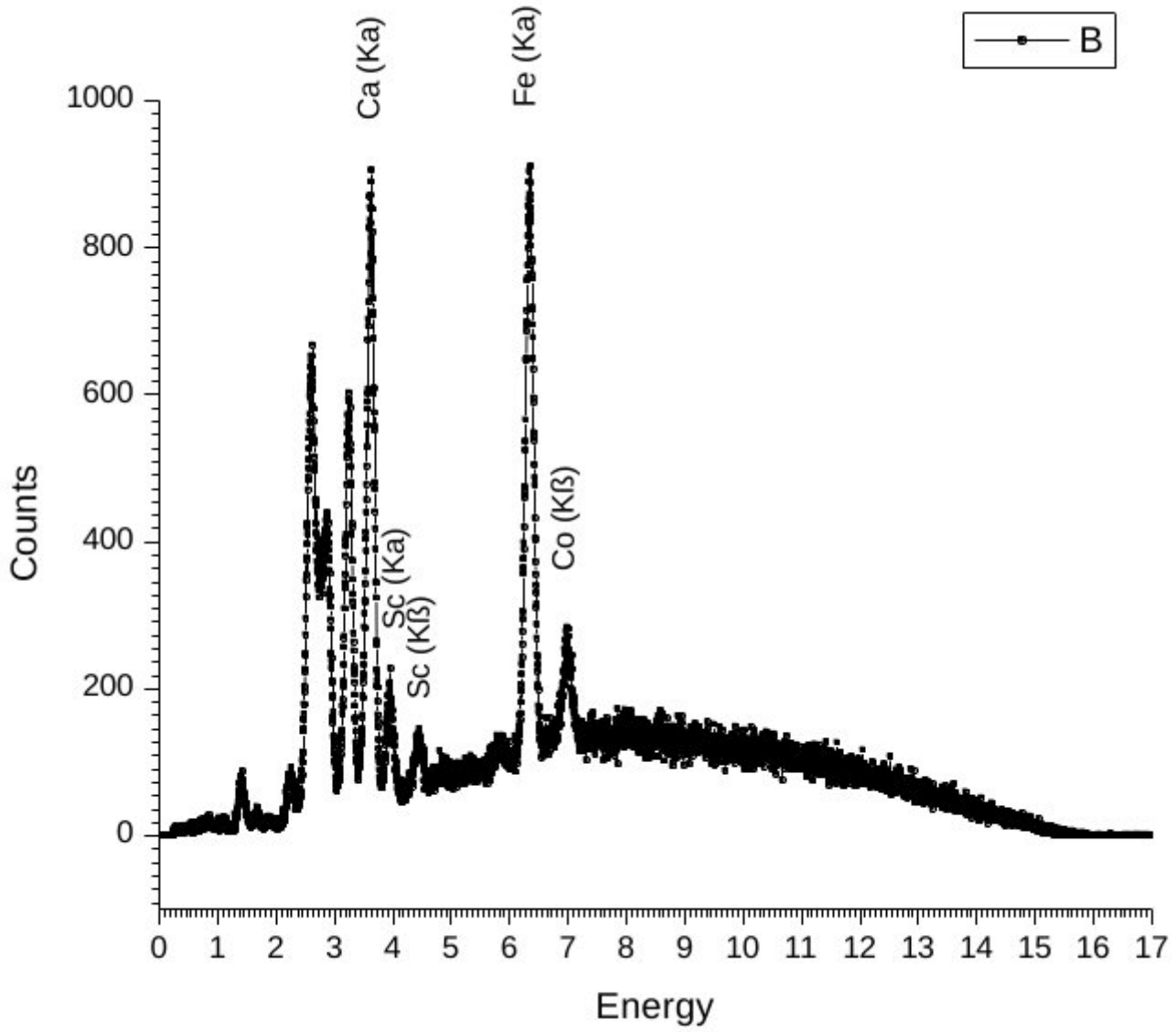


Fig 9- EDXRF spectrum of Nambadi Churma (sample no. 9)

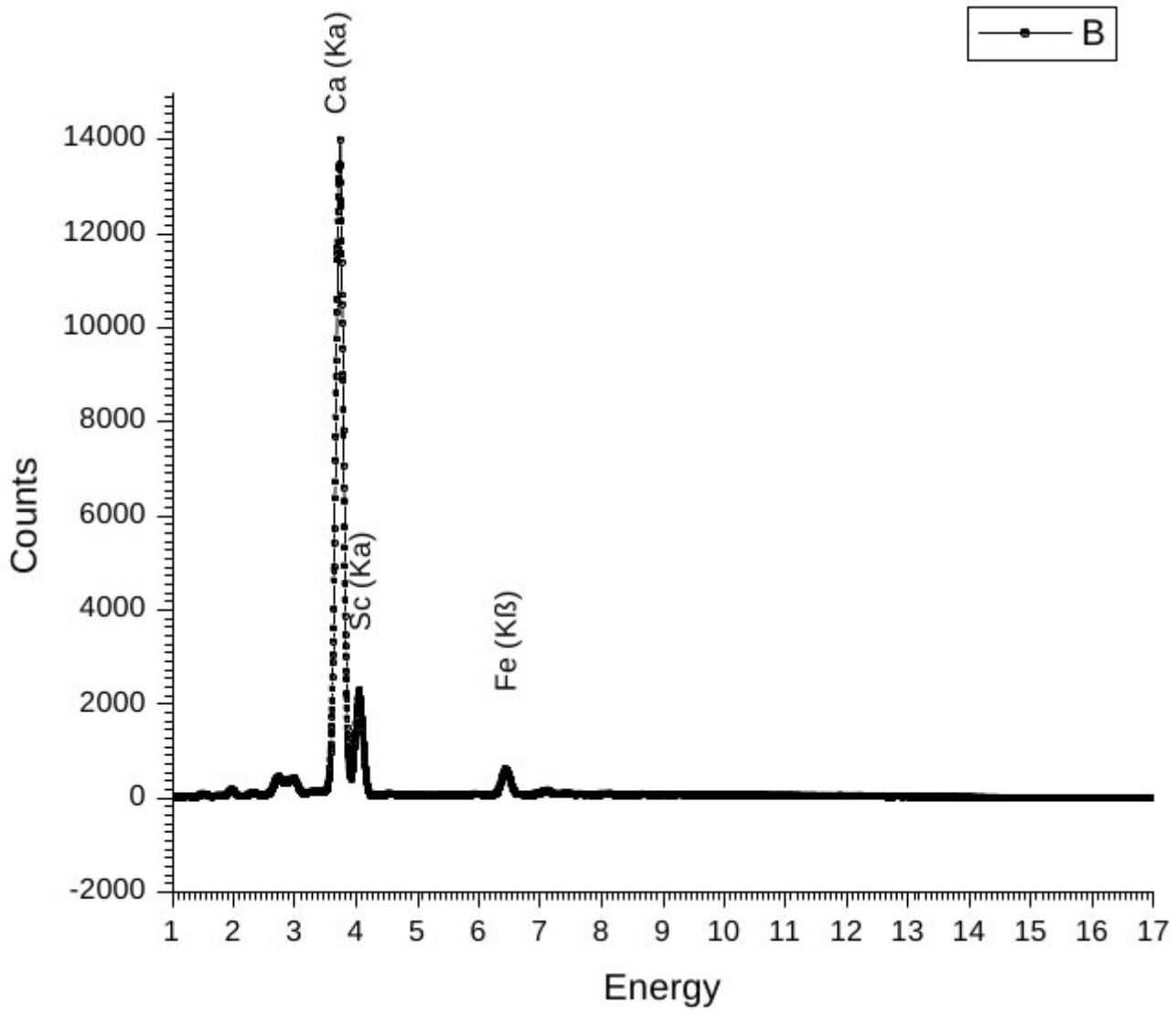


Fig 10- EDXRF spectrum of Prawal Pishti (sample no. 10)

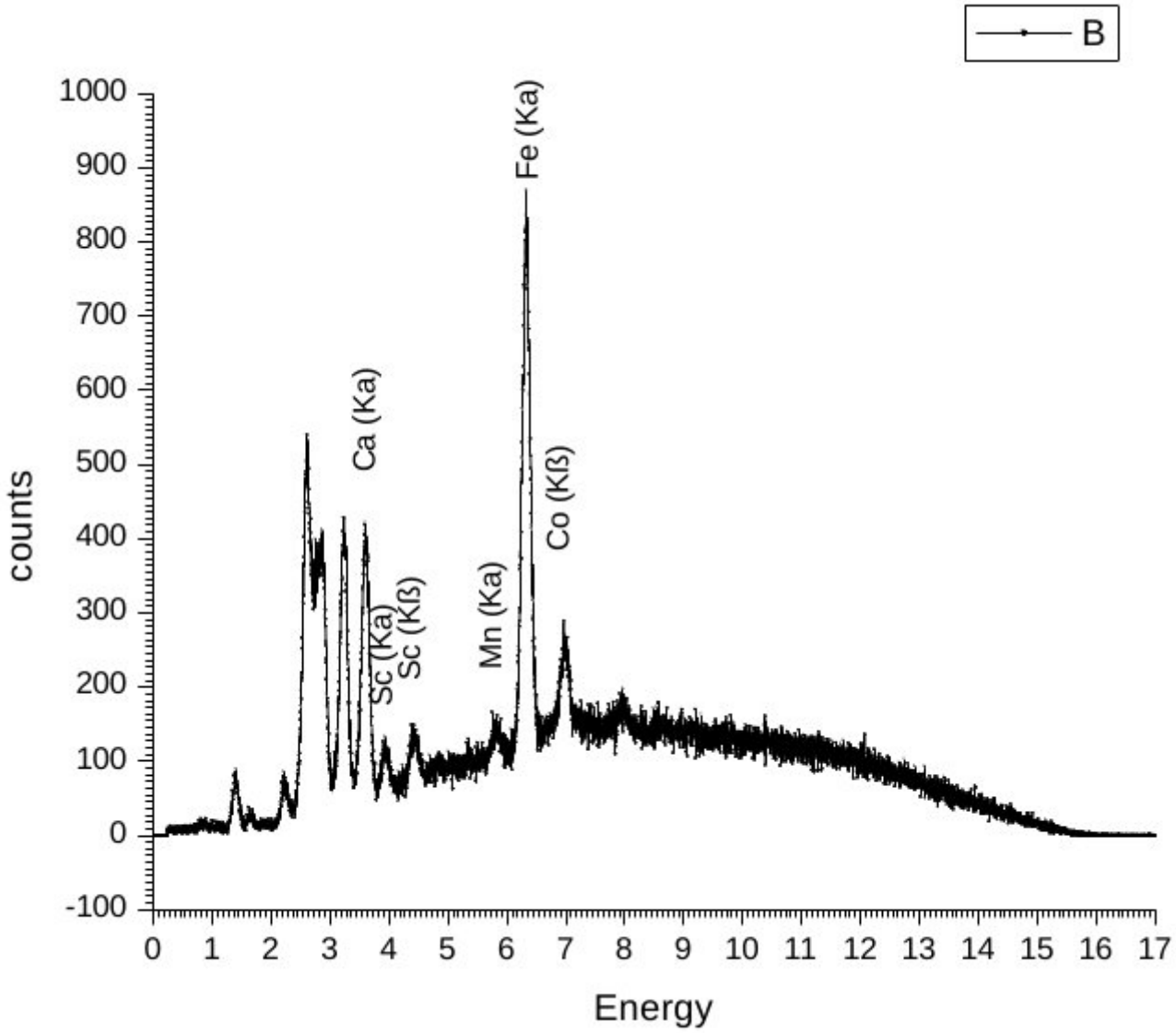


Fig 11- EDXRF spectrum of Madohar Gugloo (sample no.11)

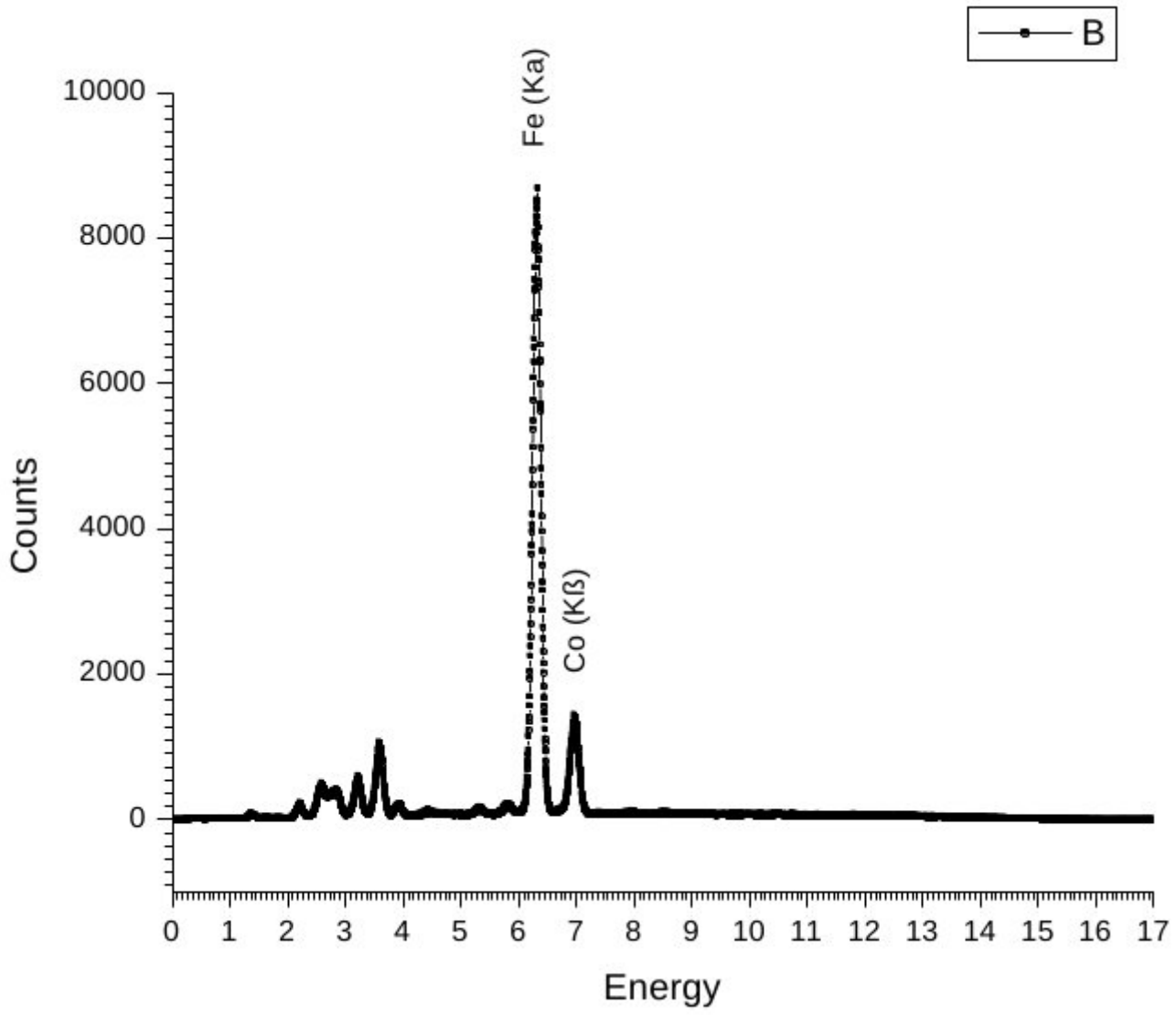


Fig 12- EDXRF spectrum of Parwatni vati (sample no. 12)

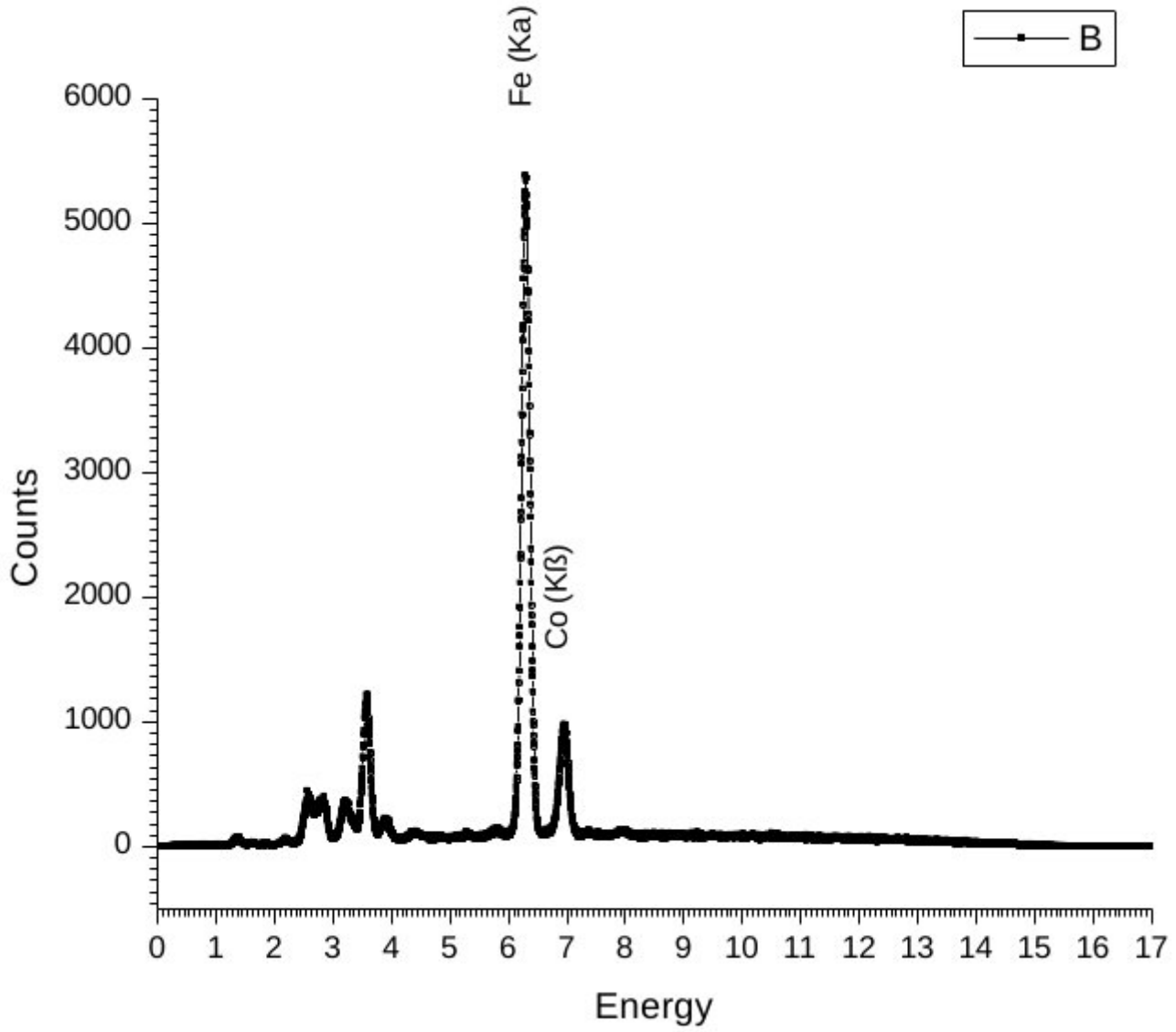


Fig 13- EDXRF spectrum of Stri Rasayan vati (sample no. 13)

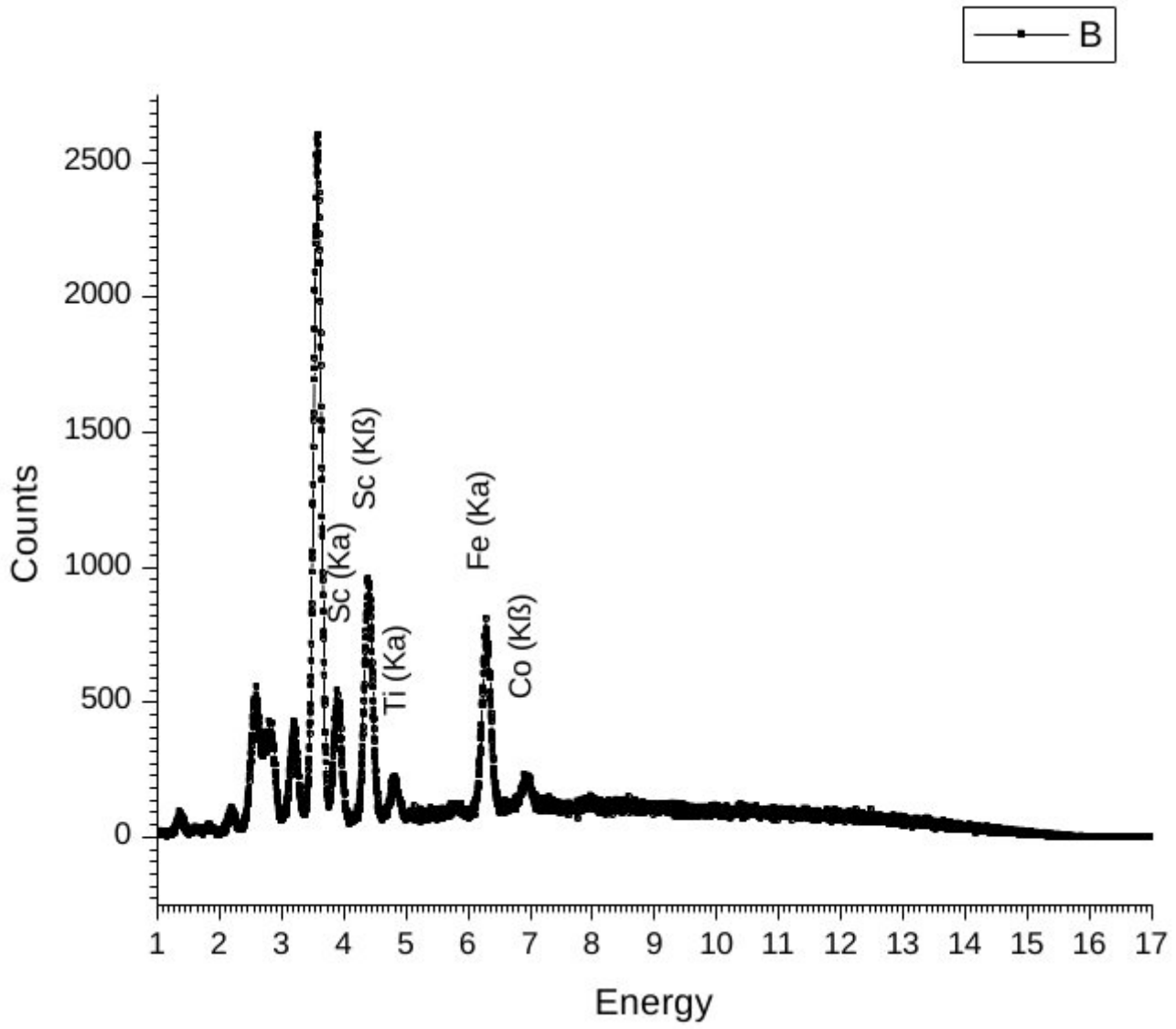


Fig 14- EDXRF spectrum of Calm- HI (sample no. 14)

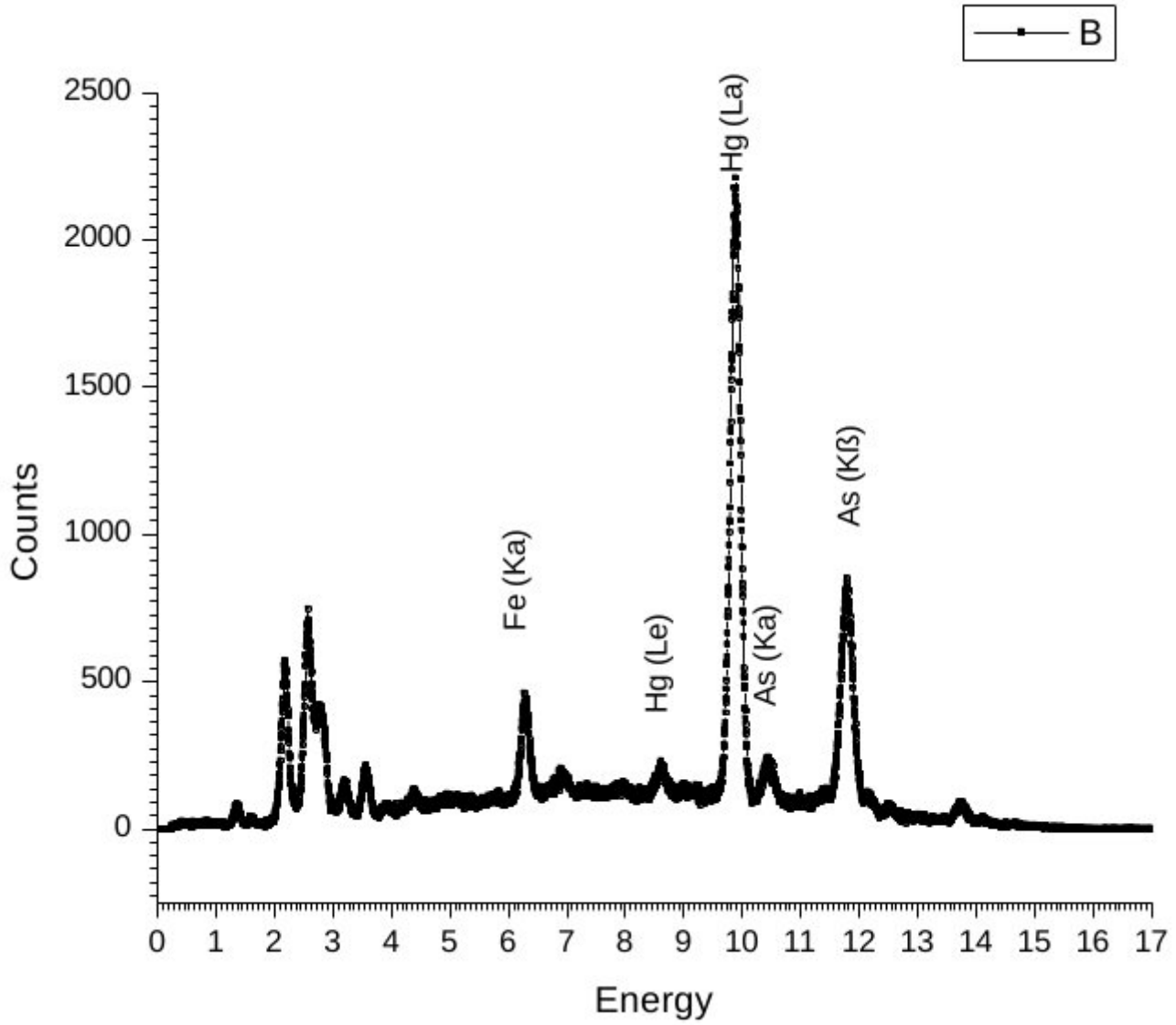


Fig 15- EDXRF spectrum of Ras Parpati (sample no. 15)

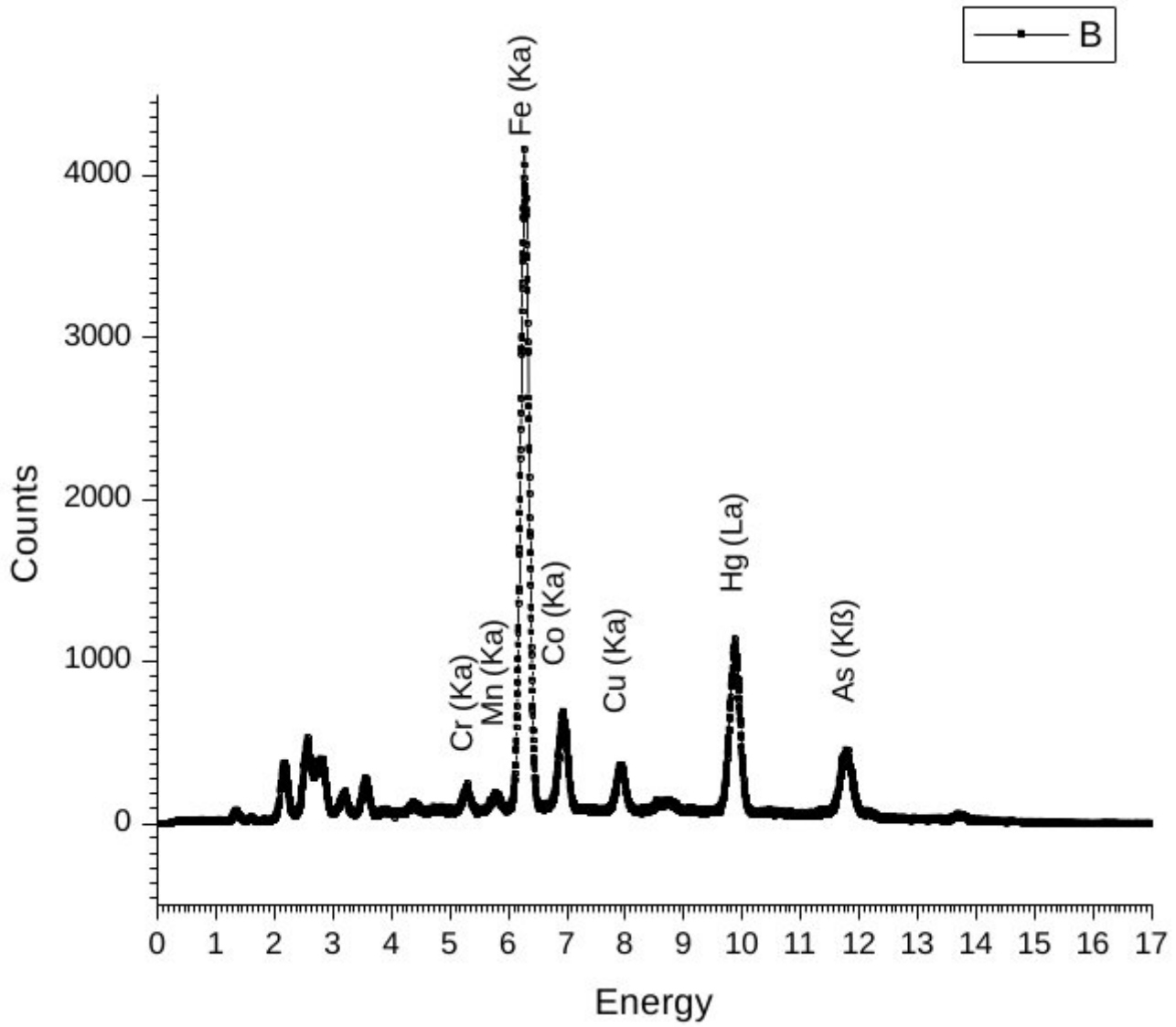


Fig 16- EDXRF spectrum of Panchamrit Parpati (sample no.16)

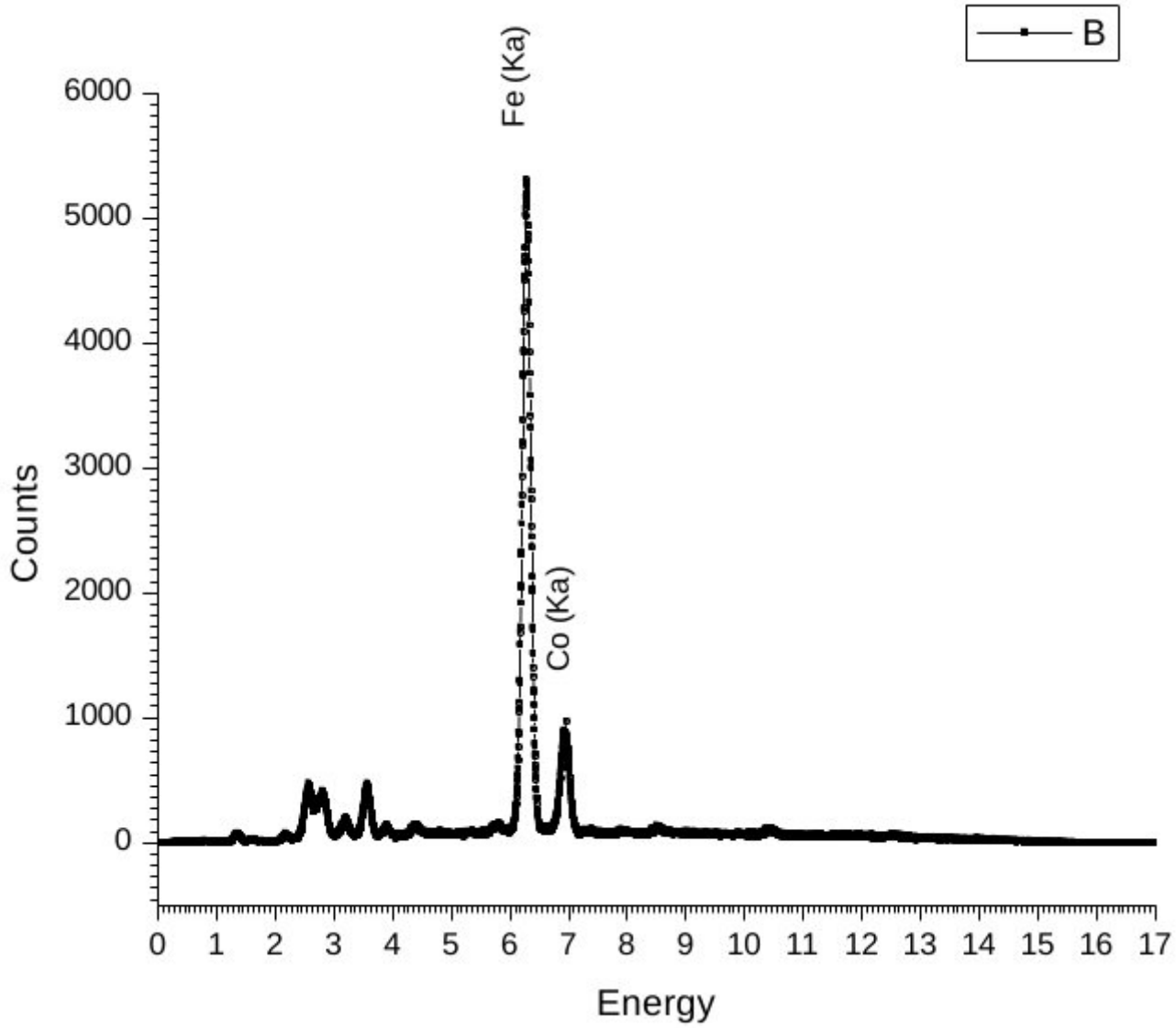


Fig 17- EDXRF spectrum of Mahayograj Gugloo (sample no. 17)

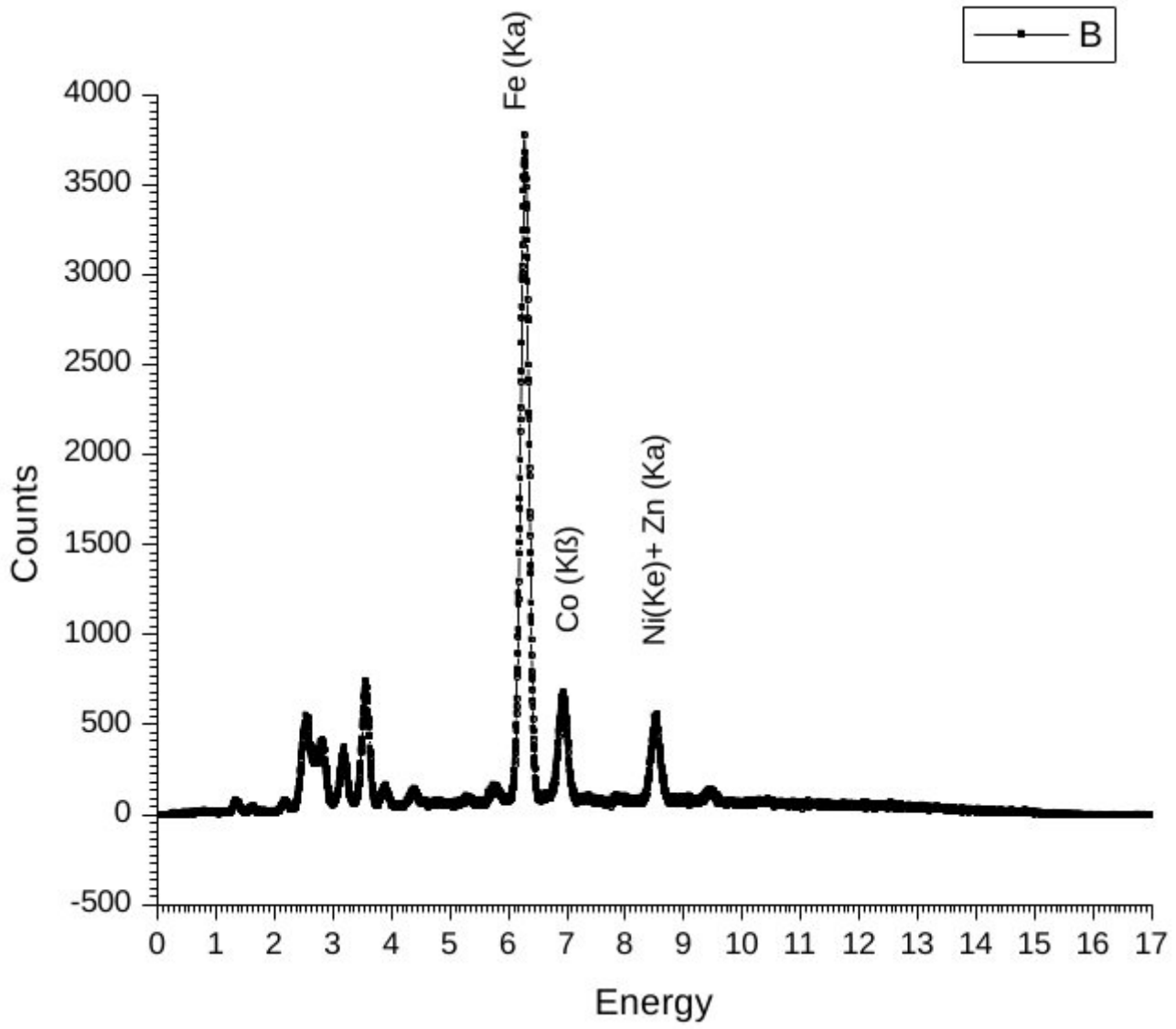


Fig 18- EDXRF spectrum of Kaishor Gugloo (sample no. 18)

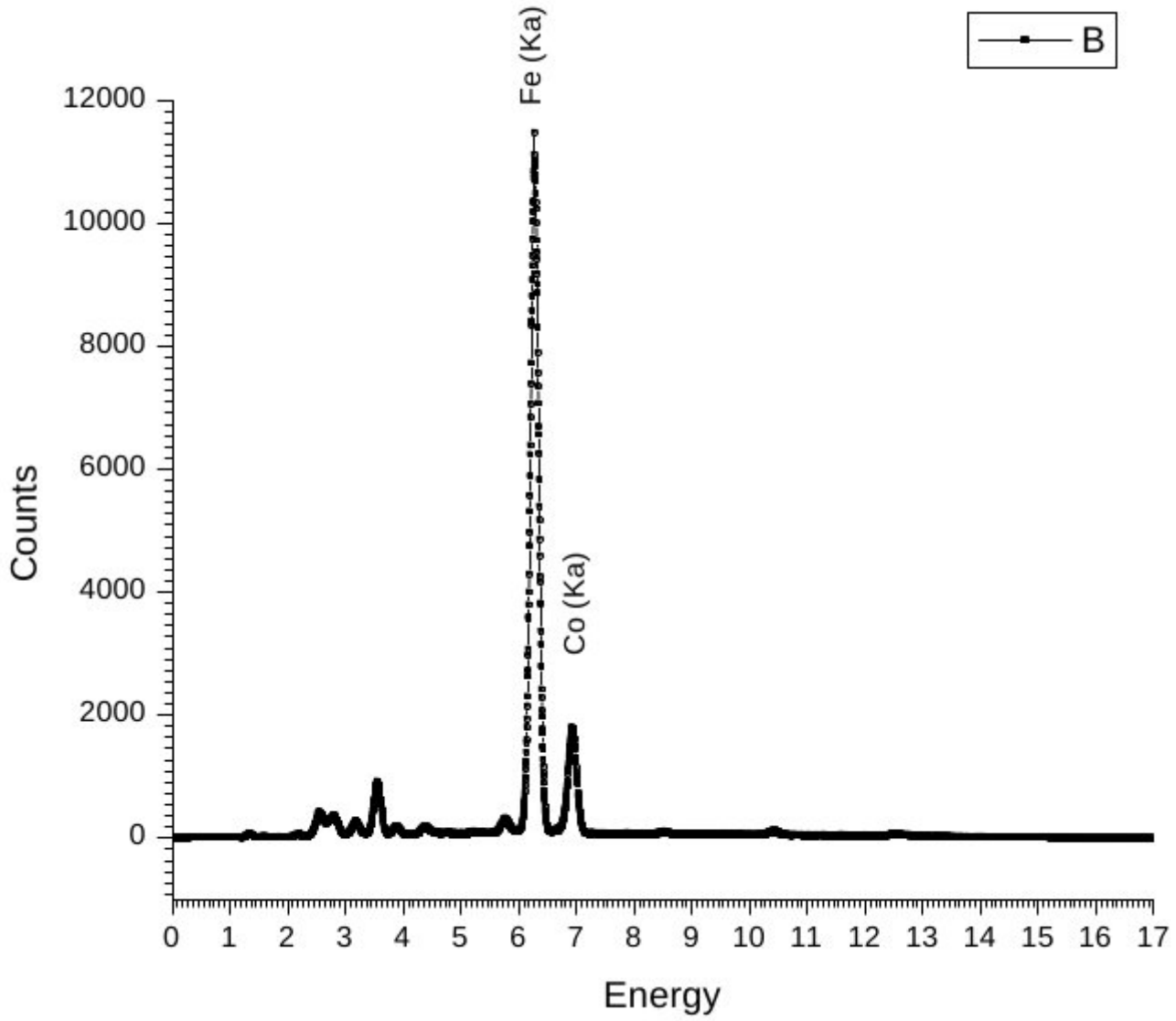


Fig 19- EDXRF spectrum of Chandraprabha Vati (sample no. 19)

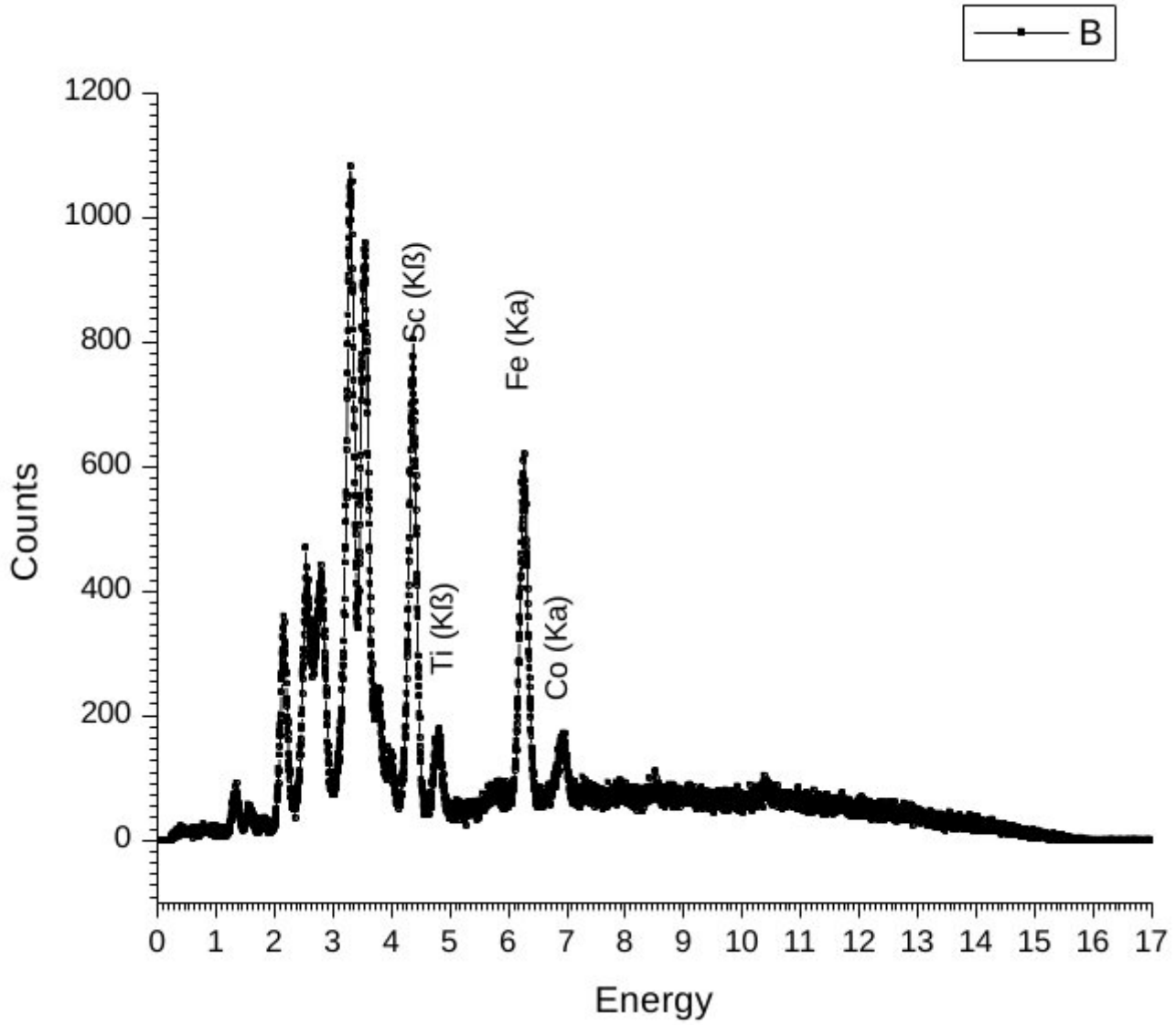


Fig 20- EDXRF spectrum of Chandraprabha Vati (sample no. 20)

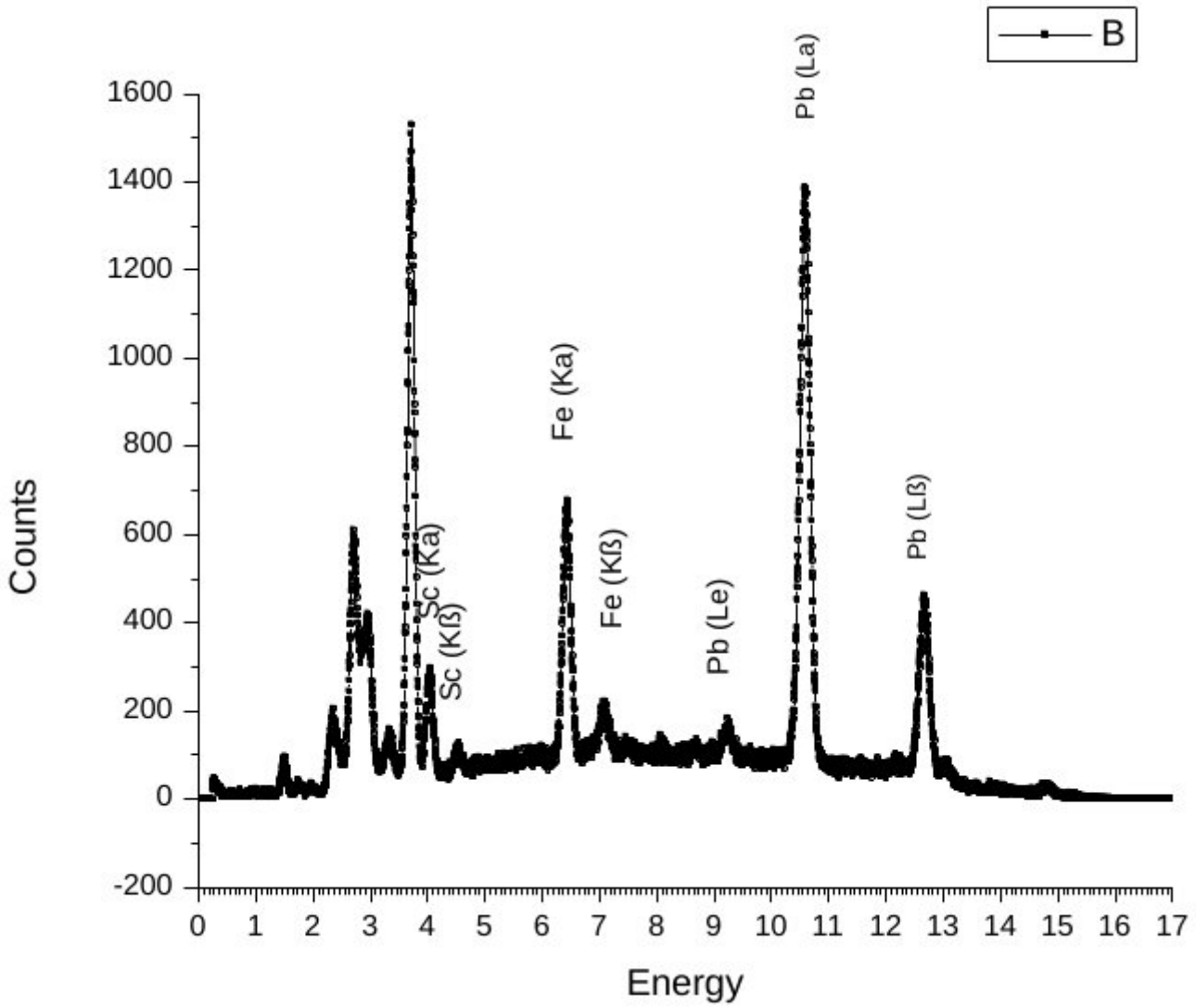


Fig. 21- EDXRF spectrum of Naag Bhasma (sample no. 21)

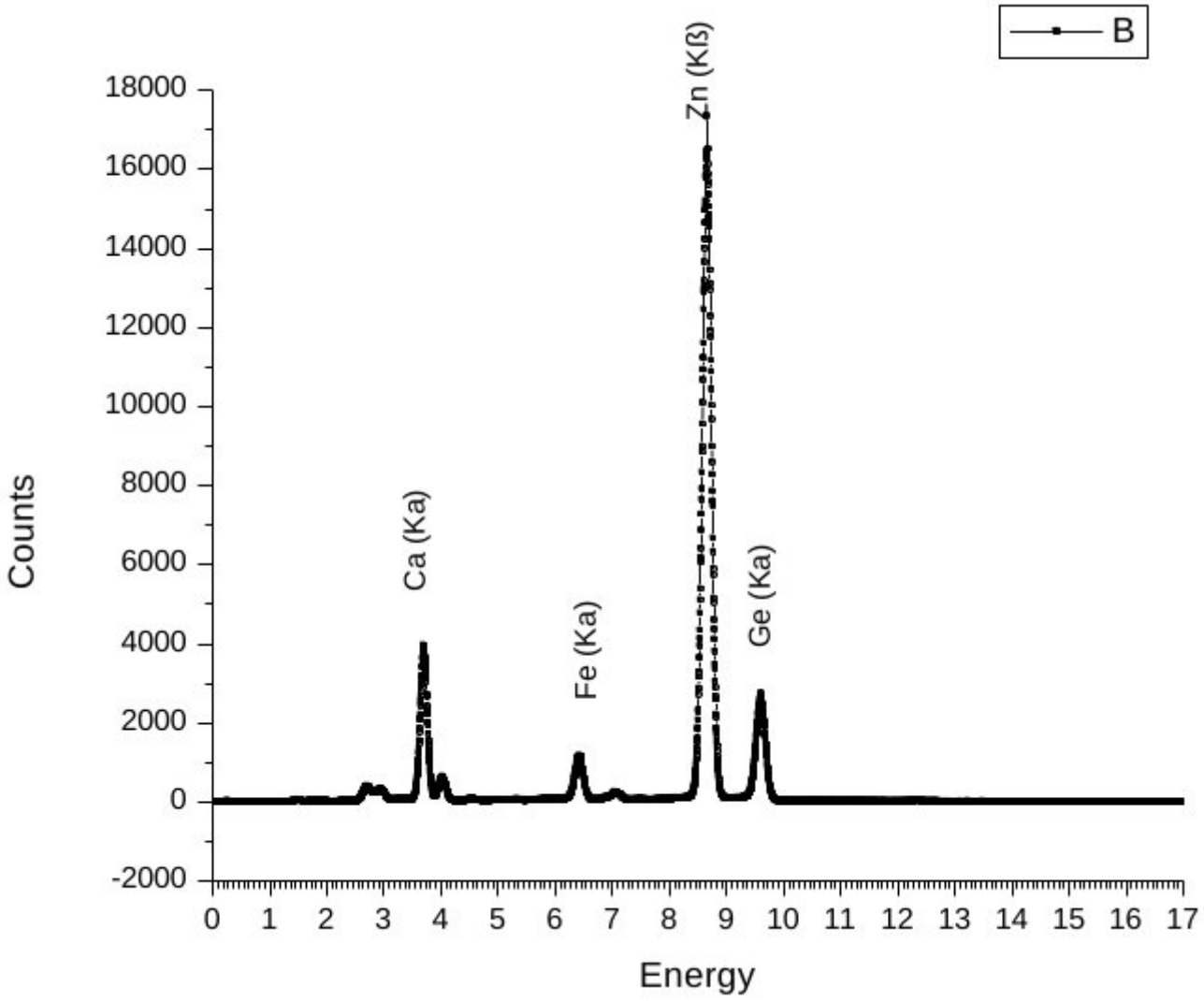


Fig.22- EDXRF spectrum of Kushta qali (sample no. 22)

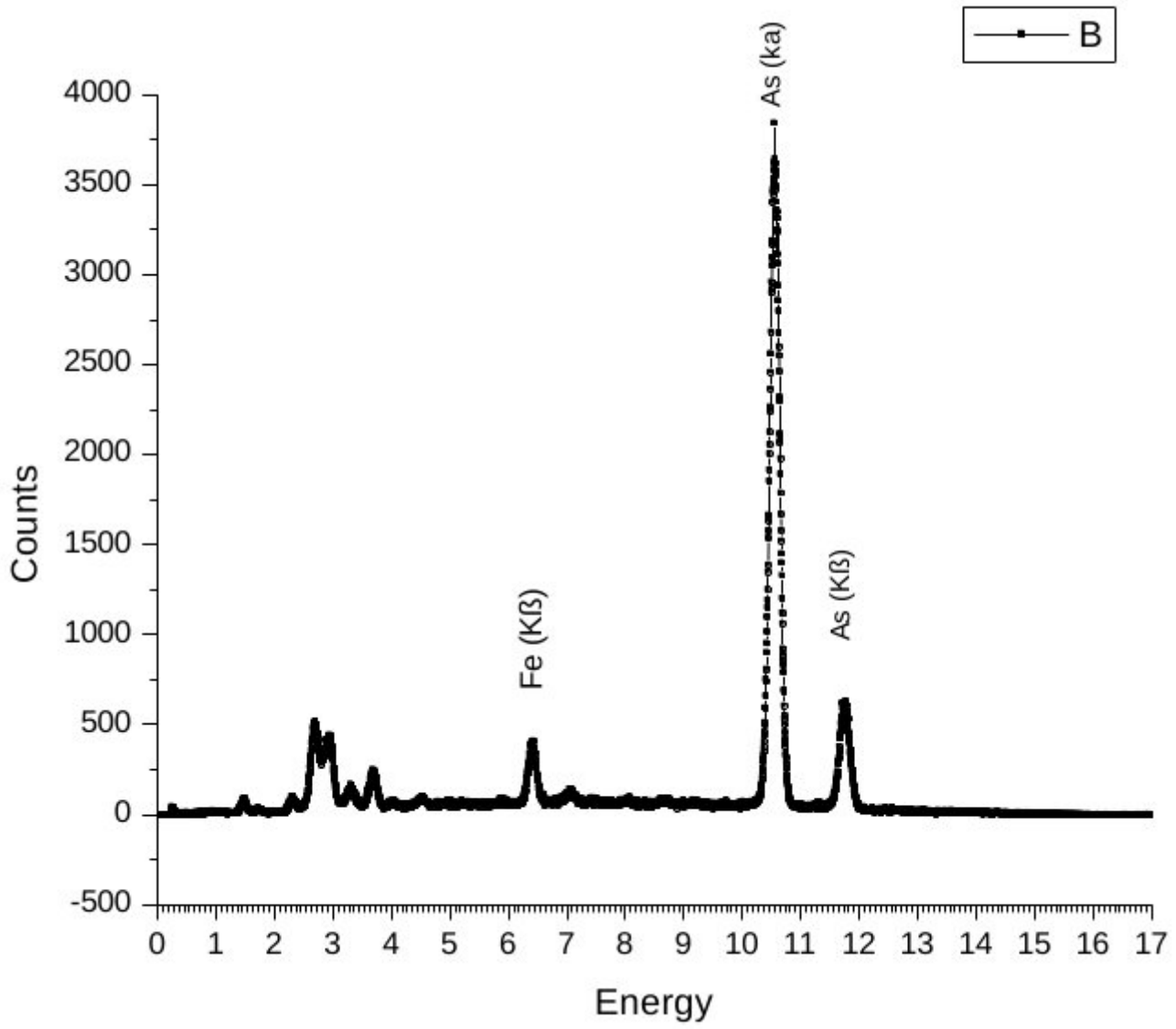


Fig 23- EDXRF spectrum of Rasamanikya (sample no. 23)

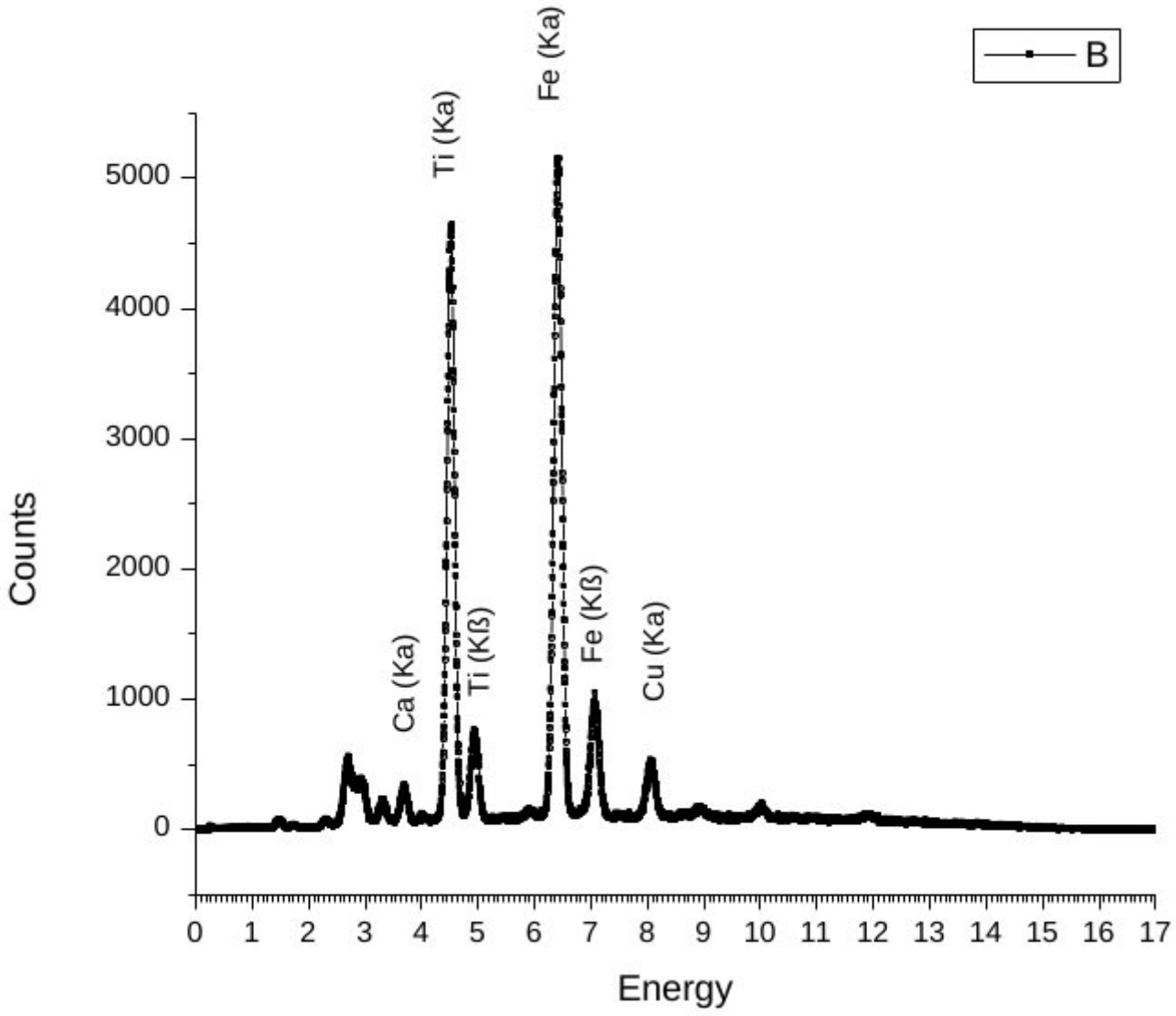


Fig 24- EDXRF spectrum of Triguliv (sample no. 24)