



ISAS newsletter

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ISAS newsletter is the quarterly email publication of Indian Society of Analytical Scientists composed and edited by
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Editor's Note:

Welcome to ISAS News Letter Volume 1, No 2. We plan to start , "Letters to Editor Column". Members of ISAS may kindly send their comments /opinions/ suggestions, etc. to the editor by e-mail. I would like to thank all the contributors for the time and effort they have spent preparing the articles for this edition which I hope will be both informative and interesting.

Role of Analytical Sciences in the Chemical Industry

Dr V.R Nair, President-ISAS

Analytical scientists working in the chemical industry are mostly engaged in process control operations. The quality of a product is often controlled by the chemical process used for its production. So control of the process is essential for optimizing a process to reduce costs, improve product quality, make processes safer and contribute to the enhancement of sustainability. Today, therefore, analytical hardware and software are designed to be integrated into a production process. With increasing pressure to reduce costs the use of process analytical tools also increases. Today's chemical manufacturers must produce chemicals more efficiently to compete in global markets and to deal with burgeoning financial exposures. Because of these factors the importance of process analytical chemists carrying out analysis online, at-line, near-line analytical methods, as well as laboratory QA/QC has increased to a great extent.

The analytical control of a production process are generally performed off-line in an analytical laboratory, at-line in the production plant itself, on-line, automatically taking a sample directly from the production, or in-line, without taking a sample from the process. All approaches from off-line to in-line are used in chemical industries. It is reported that currently about 85% of chemical production processes are batch processes, and 15% are continuous. The off-line/at-line control is often used in batch production in case the number of batches is low and the sample preparation or the analysis is difficult to automate. In continuous processes, on-line and in-line techniques are typically applied. The advantages of these techniques are a significant saving of time, robustness and user-friendliness, the latter being of great importance for shift workers in plants. In-line analysis is less prone to errors, because sample preparation is avoided.

The analytical chemistry graduates coming out of universities in our country are not familiar with these modern trends in chemical analysis. One of the main reasons for this situation is inadequate analytical curricula. The analytical chemistry education does not meet practical demands. The supply of analysts is also inadequate. ISAS is concerned about this alarming situation and is planning to take corrective action by interacting with universities and educational institutions in our country. These corrective steps are expected to strengthen analytical chemistry and improve the present situation. The analytical chemistry education curricula in India has to be revised to take care of the recent trends in process analytical chemistry. The analytical chemistry students should be trained in a variety of initiatives for enhancing the development of measurement strategies that complement new directions in manufacturing technology, including: combinatorial approaches and high throughput screening for new materials discovery (ranging from catalysis to biological materials), issues of process optimization (including development and diagnostics), and the concept of just-in-time manufacturing.

ISAS has an established track record in fostering academic/industrial/national laboratory interactions, which aim at bridging the gap between basic research and full-scale

process/product development. The ISAS is organizing workshops as part of this mission to provide continuing education opportunities in the areas of application of analytical techniques for process analysis and control. The recent workshop on mass spectrometry and related hyphenated techniques held recently was aimed at providing training mainly to student community state of the art knowledge in this area of analytical science. The ISAS workshops are held in an informal format, with technical presentations, and time allotted for both open discussion of the presentations and general brainstorming on topics that arise from this interaction. The informal environment has created a successful format for bringing together measurement scientists and process engineers from industry, government, and academic institutions drawn from both government and non government organizations. The next workshop is planned on Application of X-ray based analytical techniques in Analytical Science and Technology.



Dr P.K. Jaiswal handing over the best poster award to Ms Bolie Therattil, Research Scholar, CUSAT during IASC-2008

Indian Society of Analytical Scientists organizing International Conference on Analytical Science(*iCAS-2010*)

The Indian Society of Analytical Scientists is pleased to invite scientists from all over the world to participate in the International Conference on Analytical Science, which will be held in Cochin, during November 2010. This conference intends to gather scientists from all over the world to share and discuss recent developments in the various fields of analytical science. The symposium aims at forging an active cooperation among the participants in harnessing analytical science for economic growth, environmental management and health protection. The theme of the conference is ,

"Emerging Trends in Analytical Chemistry and Applied Spectroscopy". **iCAS 2010** is proposed to be held at Hotel Gokulam Park Inn, which is located in Cochin City, gateway to Kerala which is hailed as God's Own Country. Kerala is rated in the top three tourist destinations by the World Travel & Tourism Council and featured in National Geographic Traveler's "50 greatest places of a lifetime". The conference will highlight the relevance of analytical science as a tool in meeting the challenges and needs of modern world.

Major topics to be discussed at the conference:

- Analytical Chemistry: Philosophical Aspects
- Sampling and Sample Treatment
- Preconcentration (Including Solid Phase Extraction)
- Organic Analytical Reagents
- Chemometrics
- Quality Assurance / Quality Control
- Chromatography (GC, HPLC, IC, TLC etc.) and Related Techniques
- Atomic Spectroscopy (absorption, emission, fluorescence, XRF, XRD, lasers)
- Molecular Spectroscopy (IR, Raman)
- Mass Spectrometry
- Nuclear analytical Methods
- Electroanalytical Methods
- Geoanalytical Chemistry
- Process Analytical Chemistry
- Express Test Methods
- Surface analytical methods
- Analytical Microscopy
- Bioanalytical Chemistry
- Environmental Analysis
- Analysis of Nano Materials
- Analysis of New Materials (including High-Purity Materials)
- Analysis of Food and Agricultural Products
- Clinical Analysis

Scientists working in the fields of analytical science and related areas are invited to participate in the conference and present papers in the conference. The Conference will consist of plenary, keynote and oral lectures and poster presentations. In conjunction with the Conference there will be an exhibition of most recent developments in instrumentation, accessories and literature in analytical science and spectroscopy by manufacturers and distributors

For more information about the conference, please contact the **iCAS 2010** Secretariat:
Dr. V.R.Nair, Geethanjali, Puthalathu Kadavu Road, Near X Pius Church, North Kalamasserry, Kerala State, India,
Phone/FAX: 0091-484-2556366

0091-94473 69769

Email: isaskerala@gmail.com / nairvrdr@gmail.com / drvnrnair@yahoo.com



Photograph of the City of Cochin where *iCAS - 2010* will be held

Report on the Workshop on Mass Spectrometry and Related Hyphenated Techniques in Analytical Science

An one day workshop on Mass Spectrometry and Related Hyphenated Techniques in Analytical Science was organized by ISAS, at Hotel Bolghatty Palace, Bolghatty Island, Cochin on April 25, 2009. The workshop was inaugurated by Dr E.P. Yesodharan, Vice-President, Kerala State Council for Science, Technology and Environment. Dr V.R. Nair, President- ISAS, welcomed the participants. A book of abstracts brought out in connection with this workshop was released by Dr Ben Baars, Mass Spectrometry Specialist from Varian, Netherlands and vote of thanks was proposed by Dr Abdul Rashid, Gen. Secretary- ISAS. Eighty analytical scientists participated in the workshop. Experts in the field of Mass spectrometry and hyphenated techniques delivered lectures in the workshop. Abstracts of some of the lectures presented in the workshop are given below:

IT-1
**MASS SPECTROMETRY AND ITS APPLICATIONS TO ORGANIC
AND BIOLOGICAL CHEMISTRY**

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Mass spectrometry (MS) is one of the most powerful and versatile analytical technique for the determination of molecular weights of organic and bio-organic molecules. It is also used for elucidating the chemical structures of molecules, ranging from simple molecules to large molecules such as peptides, proteins and nucleotides and other chemical compounds. The ms principle consists of ionizing chemical compounds to generate molecule fragment ions and measurement of their mass-to-charge ratios. In a typical MS procedure, a sample is introduced into MS instrument, and its compounds are ionized by different methods of ionization (e.g., by impacting them with an electron beam, resulting in the formation of ions. The mass-to-charge ratio of the particles is then calculated from the motion of the ions as they transit through electromagnetic fields.

MS instruments consist of mainly three components: an ion source, where the analyte molecules are converted into ions; a mass analyzer, which sorts the ions by their masses by applying electromagnetic fields; and a detector, which measures the value of an indicator quantity and thus provides data for calculating the abundances of each ion present. The technique has both qualitative and quantitative uses. These include identifying unknown compounds, determining the isotopic composition of elements in a molecule, and determining the structure of a compound by observing its fragmentation. MS is now in very common use in analytical laboratories that study physical, chemical, or biological properties of a great variety of compounds.

Techniques for ionization have been key to determining what types of samples can be analyzed by mass spectrometry. Electron ionization and chemical ionization are used for volatile and thermally stable samples. Non-volatile and thermally unstable molecules are analyzed by fast atom bombardment (FAB), electrospray ionization and matrix-assisted laser desorption/ionization (MALDI).

Mass analyzers separate the ions according to their mass-to-charge ratio. There are different ms instruments based on the type of analyzer used. Some of these are sector based (magnetic and electric), quadrupole, ion traps and time of flight.

The commonly used detectors are electron multiplier and photomultiplier which detects the ions to produce ion current that is amplified and recorded using data systems.

The combination of mass spectrometers with gas chromatographs and liquid chromatographs makes mass spectrometry a powerful analytical tool to analyze complicated mixtures.

In the lecture, the basic principles including various ms ionization techniques viz., electron ionization (EI), chemical ionization (CI), fast atom bombardment (FAB), and the state-of-art mass spectrometric techniques, electrospray ionization (ESI) and matrix assisted laser desorption (MALDI) and their applications to organic and biomolecules will be discussed.

IT-2

INSTRUMENTAL CONSIDERATIONS FOR AND TRENDS IN THE ANALYSIS OF RESIDUES IN A MODERN WAY

Dr. Ben Baars, Mass Spectrometry Specialist
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In the modern world, the food safety issues are quite complicated. The industry and the regulators are facing with same issues. There are wide range of analytes (more than 1200 components on EU list) and a wide range of complex and varied commodities like fruits, vegetables, spices, animal products, water, soil, etc.

In addition to that; the regulatory limits are ever decreasing and the sensitivity demands are increasing sharply. The results are needed more rapidly with no time for separate confirmatory tests. The cost of analysis is also an important factor and highest level of confidence is required to meet/satisfy EU requirements, SANCO directives, etc. The stakes involved assumes huge importance and in this scenario; the analyst has to determine the best technique or system to meet all the requirements. This presentation covers the important considerations to be taken in selecting a technique or system and it also covers the strategy to be implemented for high through put analysis; meeting all the legal requirements.

IT-3

“AN OPTIMIST SEES OPPORTUNITY IN EVERY DIFFICULTY !” – An overview of LC/MS techniques in drug discovery game

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The constant endeavour of users of mass spectrometry and their candid challenging of the technique has led to a remarkable technological advancement in mass spectrometry, ‘married’ with separation science. In spite of the fact that the technique is more than nine decades old, over the past couple of decades, several successful attempts have been made in the area of ionisation methods, interfacing tools, different types of analysers and introduction of their hybrids to improve sensitivity, selectivity and accuracy of measurements. Though mass spectrometry has almost invaded all branches of science, its role is stupendous in the area of drug discovery. In this presentation, recent developments in various mass spectrometric techniques coupled with liquid chromatography will be discussed in detail. A couple of examples, including the identification of small molecules

on tissue surface by MS imaging, will highlight how succinct the tool is in drug discovery game!

IT-4

FLEXIBILITY OF MASS SPEC TECHNOLOGY FROM IDENTIFICATION TO STRUCTURAL ELUCIDATION

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Today more and more labs are using Mass specs for higher sensitivity in target compound analysis and better identification of unknowns. To ensure superior results and maximum value; Agilent offers a unique combination of best in class LC technology, exceptional MS spectral quality, powerful data analysis tools and optimized single source workflow solution that address a full range of qualitative and quantitative applications. New regulatory requirements means many labs need to measure food contaminants / Pharma impurities at trace levels. The new Agilent Jet stream thermal gradient focusing technology offers unparalleled sensitivity-breaking the femtogram barrier for many compounds. Learn how Agilent Jet stream technology uses super-heated Nitrogen(N₂) to improve ion generation and desolvation, delivering greater signal and reduced noise, improving detection limits by over a factor of 5 for many small molecule compounds. This presentation cites an application that demonstrates the Agilent 1200 Series RRLC, the Agilent 6500 Series Accurate Mass Q-TOF and the MetID software Agilent has the solution for the software assisted identification of known and unknown compounds in complex mixtures. The presentation discusses identification of natural products from complex plant extracts.

IT-5

ALTERNATIVES TO HYPHENATED TECHNIQUES IN MASS SPECTROMETRY

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In general, the term *hyphenated techniques* refers to the combination of spectroscopic techniques (e.g., mass spectrometry) with chromatographic techniques (e.g., liquid chromatography or gas chromatography), or the coupling of separation techniques with spectroscopic detection techniques increasing the method specificity, often in a synergistic fashion. The advantages of hyphenating analytical separation techniques to mass spectrometers have been recognized since the 1970s. LC-MS is a proven technique in the analysis of complex mixtures. However, sample preparation involves extraction of the sample with a solvent followed by proper cleanup procedures to make the sample suitable for analysis by the selected hyphenated method. In order to save time and labour mass spectrometrists have long sought a way to analyse the samples directly. Moreover,

if someone wants to know the answers to the questions such as what makes a chili pepper hot, whether or not a drug is present in a biological fluid such as blood plasma or urine, was that piece of burned carpet associated with an arson fire or not, did that bird die from pesticide poisoning or something more insidious such as VX nerve agent, he needs a fast technique which doesn't require extensive sample preparation steps.

In recent years, several direct ionization methods or ambient desorption and ionization methods have emerged.¹ Desorption electrospray ionization (DESI), Direct ionization in real time (DART), Atmospheric solid analysis probe (ASAP) and Electrospray assisted laser desorption ionization (ELDI) are a few among them. They utilize different mechanisms to create ions under ambient conditions for mass spectrometric analysis.

Ambient desorption ionization mass spectrometry allows for the direct analysis of ordinary objects in the open atmosphere of the laboratory or in their natural environment. Analyte desorption usually accompanies the ionization step and these processes are often concerted, multi-step processes. Ambient desorption ionization methods typically require little or no sample preparation, offer a much simplified work flow and deliver unprecedented ease of use to MS analyses. For example, imagine assaying biological tissue without first needing to prepare the sample or something as simple as taking a piece of carrot, showing it in the ambient ionization device and seeing the expected components like beta-carotene.

The principles and applications of some of these techniques will be discussed.

Reference

1. Andre Ventura, Marcela Nefliua and R. Graham Cooks, TrAC Trends in Analytical Chemistry, Volume 27, Issue 4, April 2008, Pages 284-290.

IT-6 HYPHENATED TECHNIQUES-LC/MS

Ms Rashi Kochar
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Mumbai

With sky rocketing increase in the stringency levels of regulatory bodies, requirement for increased accuracy in research and industry demanding high-throughput- a technique is required which can deliver the performance and yet be easy to understand and interpret.

LCMS- hyphenation of liquid chromatography (LC) and Mass spectrometry (MS) is an easily available tool which not only helps in Quantitation, but also in doubly conformation of identity both- with respect to retention-time and mass to charge ratio. Together both these parameters under a given set of chromatographic and MS conditions are fairly specific to compounds.

The core technology of LCMS lies at the interface junction of LC and MS, and it is this reason that it took decades for LCMS to come from the stage of ideation to implementation.

After some sort of separation from Chromatography, the analytes are ionized at atmospheric pressure and allowed to enter differential stages of vacuum for mass analysis. This mass analysis can take place in variety of mass analyzers/ mass filters using a fine interplay of DC/RF voltages. The ions are subsequently identified by detectors. The mass analyzer (Quadrupole/Ion-trap/Time of Flight/Magnetic sector/FTICR) of choice depends on the kind of information required from the experiment like resolution/ accurate mass calculation/basic quantitation, etc. The applications of this tool are wide spread- ranging from proteins, pharmaceutical, petroleum, polymers, forensics and Sports too! MS thus can enhance as well as assist separation of components and thus can be viewed either as an added tool or as a detector system for Liquid chromatography.

IT-7

ONLINE MONITORING OF SOLVENTS AND GASES USING PROCESS MASS SPECTROMETER AS A MEASUREMENT AND CONTROL TOOL

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T.J. Road , Abhyudaya Nagar, Mumbai – 400 033

The use of Mass spectrometry continues to grow at a very fast pace. Everyday new applications are developed as instrumentation continues to advance as fast as the needs.

Online mass spectrometry permits real time monitoring of the components in a process stream thereby giving valuable information relating to the solvent concentration trend during the process. This may be applicable in the Oleoresins / spices extraction process or even a pharmaceutical batch process.

The ability of the online mass spectrometer to cut off the process on reaching a specified end point helps in achieving a superior product quality with a higher throughput. Online mass spectrometry application can also be extended to gas analysis in the field of nuclear research / space / coal gasification and catalysis research besides upcoming areas like fuel cell technology.

This workshop was attended by both junior and senior level analytical scientists and this workshop provided them an opportunity and forum to exchange ideas and experience.

During the feed back session the participants suggested that ISAS should conduct more such workshops on emerging techniques in the area of analytical sciences.

**INVESTIGATIONS OF METAL VARIATION AND ITS IMPLICATIONS IN
VARIOUS INDIAN MUSTARD GENOTYPES USING RADIOISOTOPE
INDUCED ENERGY DISPERSIVE X-RAY FLUORESCENCE TECHNIQUE.**

Daisy Joseph

Nuclear Physics Division, B.A.R.C, Trombay, Mumbai-400085

ABSTRACT

Metal ions are utilized by the biological systems in several fundamental metabolic and developmental processes. The essential transition metals are used by cells as cofactors of enzymes or proteins and they contribute to their activity. Therefore the chemistry of a cell needs to be characterized not only by its characteristic genome but also by the metal and metal distribution among the different plant species. An attempt has been made to obtain metal differences in various mustard genotypes and correlate them to salt tolerance sensitivity, by using an X-ray spectrometer consisting of a, Radioisotope source of Cd¹⁰⁹ and an X-ray detector Si(Li) of resolution 170 eV at 5.9 keV Mn K-X-ray and its associated electronics. Fourteen mustard genotypes were powdered, dried and palletized and then analyzed. K, Ca, Mn, Fe, Cu, Zn, Br and Rb were detected at ppm levels. Their presence and significance of the elements in plant growth will be discussed in the following sections of the paper.

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Introduction

The process of mineral uptake by plants has been extensively investigated [1,2]. Mineral uptake into plants grown in vitro is dependent on the supply in the medium. However, the supply depends not only on what is added to the medium at the time of preparation but also on the availability of those minerals to the plant. Availability of minerals depends up on solubility of the ions after any chemical changes that may occur in the medium, while the nutrient supply to the plant in the medium does not have access to the entire volume

of the medium. Numerous studies have investigated relationship between mineral nutrition and explants growth [3,4, 5, 6, 7,8] However few studies have explored the role of minerals in the regulation of in vitro development [.9] (Ramage and Williams 2002a).

X-ray emission techniques (EDXRF and PIXE) have been found to be useful in obtaining trace element profiles, and their significance in biological system is well known [10,11]. Energy-dispersive X-ray fluorescence technique (EDXRF) was used to determine trace element profiles [12, 13] in different biological systems.

In the present study an attempt has been made to study the accumulation of different trace elements in mustard seeds of different genotypes. Thus the evaluation of trace element accumulation may help in establishing correct culture media for the induction of high yield plant. Indian mustard plants (*B. nigra* L.) are well adopted to tolerate and accumulate high quantities of trace elements due to increased level of antioxidants (cysteine and ascorbic acid) in root, shoot and leaves of the treated plants at all the concentrations and exposure periods except

Materials and Methods:

Mustard seeds of 14 varieties frozen in liquid nitrogen and ground to a fine powder and was lyophilized using liquid nitrogen. The powder samples then homogenized with cellulose binder and pressed with a pelleting machine under pressure of 15 tons/in² to make self supporting pellets of diameter 2.5 cm and weight 350mg. These pellets were then mounted in front of an EDXRF setup consisting of a Semiconductor detector Si (Li) of resolution 170 eV at 5.9 keV Mn K_α X-rays. The samples were excited using a ¹⁰⁹Cd source and the fluorescent X-ray peaks were used to calculate the concentrations of elements in the sample using a computer code. The concentrations of the elements were computed using the formula.

$$I_j = I_0 G m_j K_j C$$

Where, I_j is the intensity of the j th X-ray line; I_0 is the intensity of exciting source, G is the geometrical factor, m_j is the concentration of the j th element, K_j is the excitation detection factor and C_j is the matrix absorption correction factor. The geometrical factor $I_0 G$ was obtained using an yttrium standard of known concentration (320ppm) of the same diameters prepared in a similar manner as the samples. The concentration of the j th element was then calculated using $I_0 G$, the measured values of I_j and C_j , and the known values of K_j . In a separate experiments, the sample in between the detector and the source and measuring the transmission of X-ray energies of known sample through the known sample. The intensities of X-rays were then noted to obtain the absorption factors for each sample at these energies by using the equation $I = I_0 e^{-\mu x}$, where μ is the mass absorption coefficients for incident and fluorescent energies, respectively. The value of C_j in the above equation is obtained by $C_j = 1 - e^{-(\mu_1 + \mu_2)x} / (\mu_1 + \mu_2)x$, where μ_1 and μ_2 are the mass absorption coefficients for incident and fluorescent energies, respectively. The absorption correction for X-rays of each element present in the sample was obtained by interpolation of the measured mass absorption coefficients as obtained by the above method.

Results and Discussion

Table I gives the elemental concentrations of the mustard seeds of different genotypes and Figs 1-14 give the X-ray spectra of all varieties of the mustard seeds. It is seen that K and Ca are the significant elements which are essential elements for plant growth, followed by Fe. Calcium has an important role in the mediating plant response to osmotic stress with inhibitors of Ca^{2+} uptake or Ca^{2+} -binding proteins affecting plant salt tolerance.[14] (Knight, 2000). Different plant cells may play different role to Ca^{2+} . [15] (Kiegle et al., 2002). More generally calcium plays a central role in cell signaling [16] (Sanders et al., 2002).It is observed that Ca is significantly present in CS-54.While K and Ca is significantly present in CS-52, the other elements are not so. Iron is an essential micronutrient however the insolubility of iron limits its uptake. Recently iron transport protein (ITP) was purified from Arabidopsis and through sequencing of its cDNA, was shown to have strong similarity to late embryogenesis abundant proteins from a number of species [17] (Kruger et al., 2002). Similarly in the present study, slightly higher accumulation of iron was observed in Ashirwad and CS-54 genotype as compared to the other varieties. Other elements like Cu, Zn, Rb, Sr which are toxic to plants, after a certain limit is seen to be present at a lower level

Conclusion

The focus of the present finding supports our finding of Indian mustard being a potential and profitable alternative oilseed crop as it does not reveal presence of any high level of toxic elements which could hamper plant growth and it could be used for further evaluation of the role of these (over accumulating) trace elements in different concentrations in culture media for formulating a media for induction of high embryogenesis in mustard cultivation.

Table I:
Concentrations of trace elements in mustard seeds in ppm

	K	Ca	Fe	Cu	Zn	Rb	Sr
Pusa b	1082±58	461±31	13±31	ND	2± 1	1	4
Kranti	803±47	569±33	18±2	4±1	3± 1	1	5
Gm-1	942±53	622±34	13±1	1±0	2± 1	1	5
Gm-3	742±58	455±32	8±1	1±0	1± 1	1	3
RL-1359	746±57	431±31	7±1	1± 0	1± 1	1	4
Varuna	914±43	568±26	14±1	3±1	3± 1	1	4
Rh-30	1163±63	298±35	7±2	1± 1	1± 1	1	3
Rohini	896± 58	456±33	9±1	0±0	1±1	1	3
Vardan	932±58	438±31	6±1	2± 0	3± 1	1	3
Urvashi	761±56	443±31	9±1	1±0	2± 1	1	3
Maya	602±52	379±27	10±2	ND	1± 1	1	3
Ashirwad	431±61	374±35	33±2	ND	ND	ND	2
Cs-52	1621±79	1103±47	26±2	2± 1	4± 1	2	9
Cs-54	586±92	580±51	41±3	8±2	1± 0	1± 1	

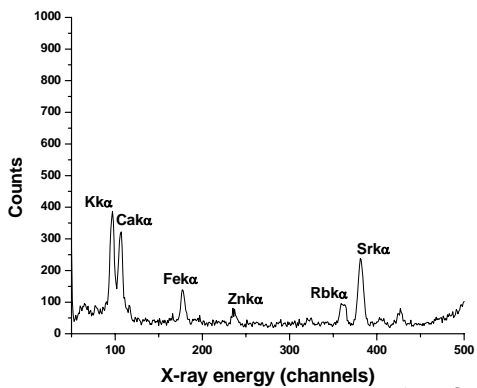


Fig 1: X-ray spectrum of PUSA

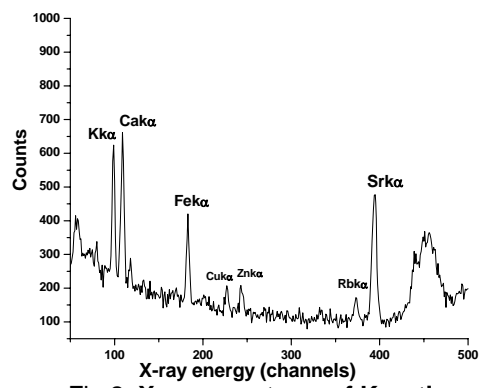


Fig 2: X-ray spectrum of Kranti

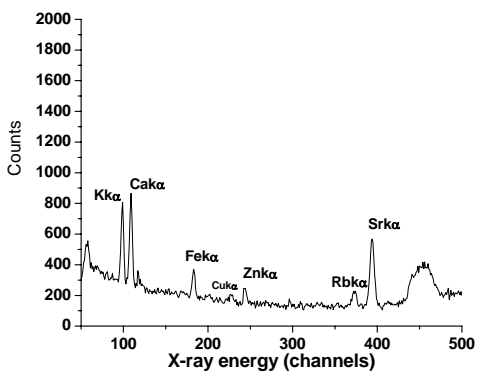


Fig3 : X-ray spectrum of Gm-1

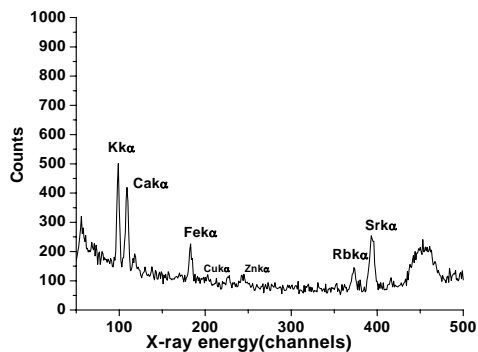


Fig 4: X-ray spectrum of Gm-3

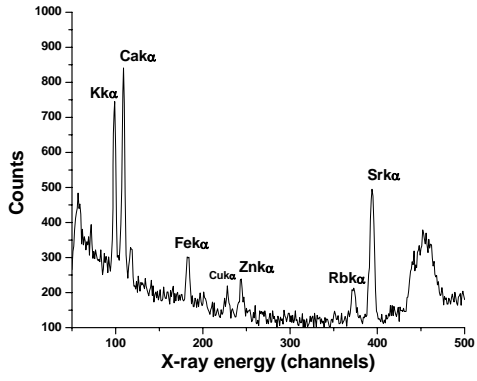


Fig 5: X-ray spectrum of RL-1359

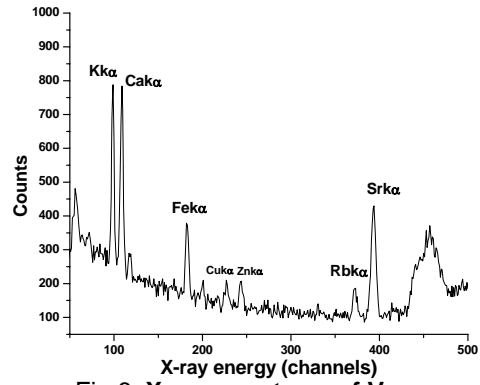


Fig 6: X-ray spectrum of Varuna

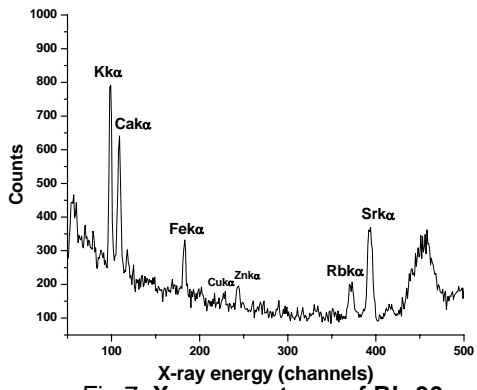


Fig 7: X-ray spectrum of Rh-30

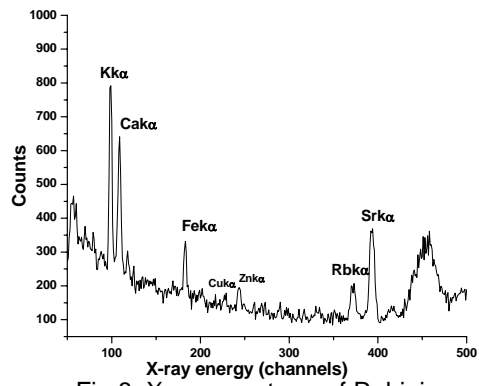


Fig 8: X-ray spectrum of Rohini

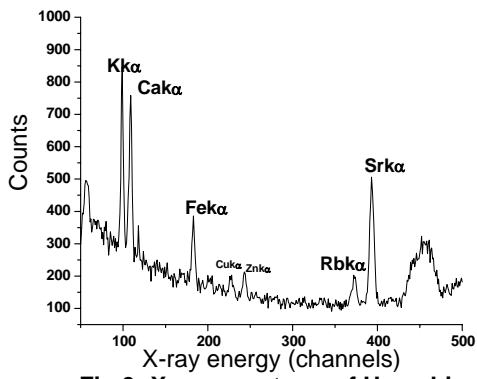


Fig 9: X-ray spectrum of Urvashi

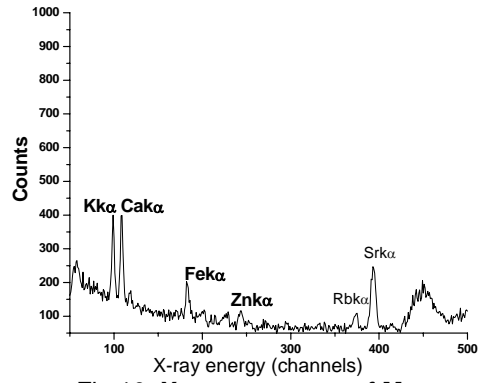


Fig 10: X-ray spectrum of Maya

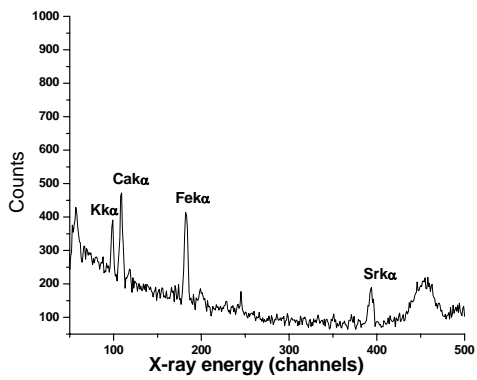


Fig 11: X-ray spectrum of Ashirwad

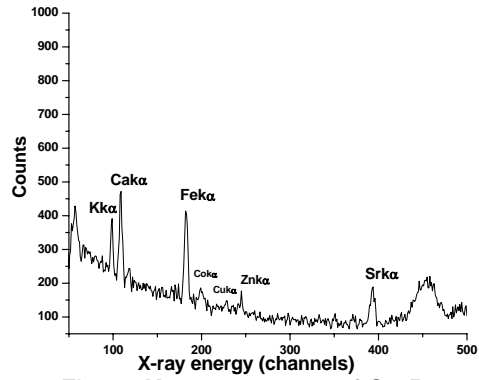


Fig 12: X-ray spectrum of Cs-54

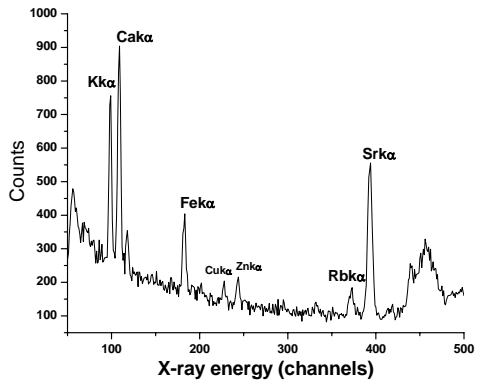


Fig 13: X-ray spectrum of Cs-52

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