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Forensic Science

"Nondestructive Authenticity of Postage Stamp: New Approach In Questioned Document Examination"

Mr. Dinesh Kamble	Assitant Professor, Shri Vaishanv Institute of Forensic Science, SVVV, Indore
Mr. Mayur Abhyankar	Post Graduate Student, Institute of Forensic Science, Mumbai
Ms. Sherali Sharma	Graduate Student, Shri Vaishanv Institute of Forensic Science, SVVV, Indore.

ABSTRACT A postage stamp is a small piece of paper that is purchased and displayed on an item of post mail as an evidence of payment of postage. In India postal stamps have various denominations varying from one to twenty five thousand rupees. Postal stamp was a token of prepayment for postal service equivalent to its face value. In India stamps are printed on special custom-made paper, show a national designation and denomination (value) on the front, and have an adhesive gum on the back or are self-adhesive, under supervision of central government of India. In India, counterfeiting of currency and postal stamps is a major issue which has become a blunder to the Indian economy. There were so many cases which were reported in India, of counterfeiting the postal stamps, by using colour printing technology. In this study we took few postal stamps of various denominations and its coloured photocopy and characterize through non-destructive method by X-ray Diffraction. X-ray Diffraction is a generally nondestructive forensic analysis tool that reveals the crystalline constituent present in the material. X-ray diffraction has been used for more than 30 years, sometimes in conjunction with other analytical methods, to differentiate philatelic printing techniques; to separate genuine stamps from forgeries. Here we reported that X-ray Diffraction is a valid instrument to separate genuine postage stamps from counterfeited.

KEYWORDS : Questioned Document Examination, Document Authenticity, X-ray Diffraction.

1. Introduction-: The characterization of papers is an important aspect in forensic science work for differentiation of documents, papers which are composed of various ingredients like inorganic fillers as well as organic material used according to the sizes, coloring agents etc. [Browning, 1969] Differentiation of sheets of paper is an important examination in QDE, in cases in which anonymous of papers are involved such as agreement contain papers which can be easily substituted by anyone without the consent of the involved parties, in such cases the nature of questioned paper is different with respect to other documents [V. Causin et. all, 2010]. Proton Induced X-ray Emission has been used for more than 30 years, sometimes in conjunction with other analytical methods, to differentiate philatelic printing techniques; to quantify differences between different shades, varieties, and reprints of stamps; and to separate genuine stamps from forgeries [Thomas E. Gill, 2013]. It is conceptually similar to X-ray fluorescence spectrometry (XRF), which has also been used for analysis of stamps [Preiss and Robie, 1982; Cesareo and Brunetti, 2008; Jelovica Badovinac et al., 2010]. In forensic analyses of inks and papers [Cahill et al., 1981; Thompson, 1983; Kusko, 1988], especially after it was used to reveal the printing methods and materials of the "Gutenberg Bible" [Schwab et al., 1983]. Since then, reviews of this technique inevitably mention its application for analysis of historical printed documents [Johanson, 1989, 1992; Demortier, 1991; Pillay, 2000; Vijayan et al., 2003; Vodopivec et al., 2005]. A number of techniques have been proposed for differentiation of paper which are X-ray diffraction [D. Ellen, 1997, J.S. Kelly, B.S. Lindblom, 2006, H.A. Foner, N. Adan, 1983, J. Levinson, 2001, L.D. Spence et. all. 2001], elemental analysis [L.D. Spence, 2000, L.D. Spence, 2002], IR spectroscopy [J. Andrasko, 1997, A. Kher et. all., 2001, A. Kher et. all., 2005], Raman spectroscopy [A.H. Kuptsov, 1994], image analysis [H. Miyata, 2011] and pyrolysis gas chromatography [H. Ebara et. all., 1982]. The degree of cellulose crystallinity in the paper documents can be considered as one of the parameters in the differentiation of paper based documents in questioned document examination. In this study we focused on differentiation of postage stamps by degree of cellulose crystallinity and inorganic fillers present in postage stamps by X-ray diffraction through nondestructive method. An assessment of analyzed data is very useful while interpreting results and presenting them to Court.

We have taken total 4 postal stamps, of denominations 2 rupee, 3 rupee, 5 rupee and revenue stamp, for the sampling purpose. After the collection of postal stamps, the coloured prints of these postal stamps were taken out for the purpose of comparison with the help of XRD. The original stamps were denoted as specimens 1 & 2 and the coloured print outs were named as questioned postal stamp. Each postal stamp was taken one by one and was analyzed for their composition. After this the coloured print outs of the postal stamps were taken for the analysis under the XRD. The graphs of both the stamps that is specimen postal stamp and questioned postal stamp were analyzed.

2. Methods

Table. 1.

Sr. no.	Sample Labels and Denominations	Specimen 1	Specimen 2
1	A (2 Rupee)	A_1	A_2
2	RA (3 Rupee)	Ra_1	Ra_2
3	L (5 Rupee)	L_1	L_2
4	R (Revenue Stamp)	R_1	R_2

2.1. Sampling Table 1. shows postage stamps of various denominations were collected from head post office of Mumbai in India. The postage stamps samples were labeled by a capital letter, the denomination of the postage stamps used for this study are indicated and also shows labeling of respective color photocopy of each postage stamps for comparison with original postage stamps. A preliminary observation under visible light and ultraviolet examination did not allow to differentiating the samples, i.e. they looked similar in color and texture.

2.2. X-ray diffraction -:

XRD patterns of these samples were recorded in the diffraction range 8–60 2theta by a diffractometer GD 2000 (Ital Structures) working in a Seeman-Bohlin geometer and with a quartz crystal monochromator on the X-Ray 30kV/15mA. The diffraction patterns were fitted by a least-squares fit procedure elaborated [Hindeleh and Johnson, 1971]. Samples were mounted in two directions: with the X-

ray beam parallel to the width and to the height, respectively, of each postage stamp. In a preliminary phase, two replicates were taken for genuine postal samples as R1 and R2, RA1 and RA2, L1 and L2 and A1 & A2. It was seen that the repeatability of the measurements was very good and that the obtained genuine postage stamps diffractograms mostly were superimposable and along with counterfeited postage stamps diffractograms were taken for comparison with genuine postage stamps. X axis shows 2theta value and Y axis shows the intensity.

Fig. 3: Sample loading on goniometer.

Result & Discussion-:

Fig. 4 shows a postage stamp XRD that was obtained from one specimen postage stamp. These peaks are due to cellulose, which is the polymetric matrix which constitutes the postage stamp, and Fig. 5 shows that beside cellulose peaks, there are some other peaks present due to the inorganic fillers which are added to confer good physical-mechanical properties of postage stamps.

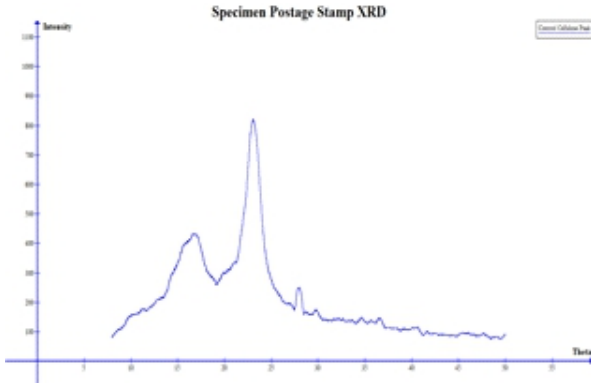

Fig. 4: XRD of Specimen Postage Stamp

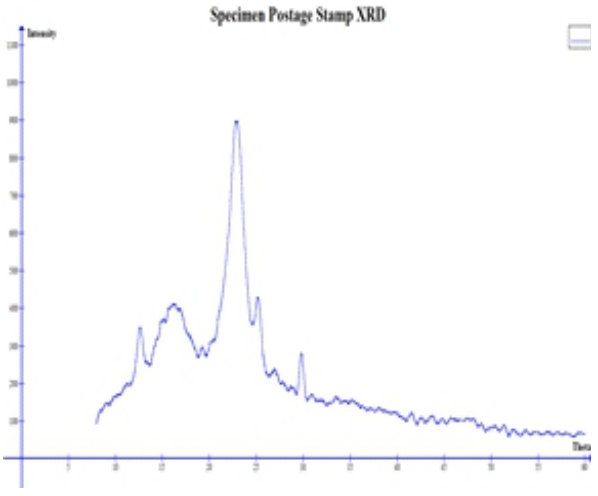

Fig. 5: XRD of Specimen Postage Stamp

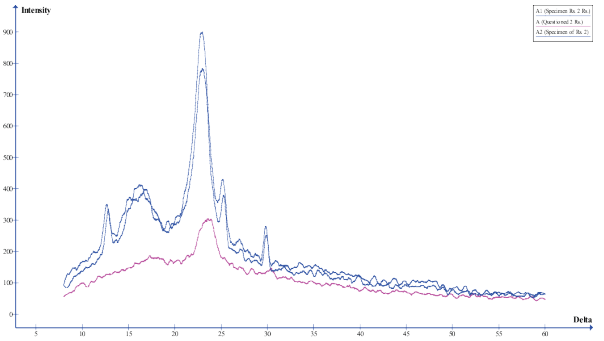

Fig. 6: Graph for postage stamp of 2 rupee.

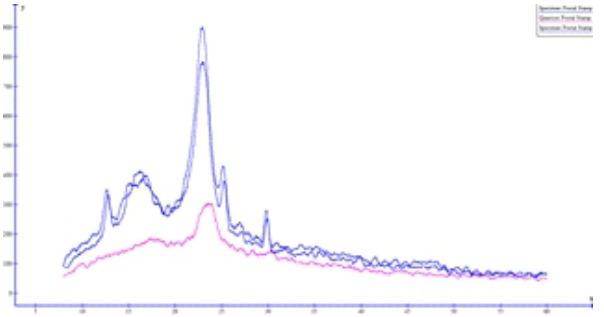

Fig 7: Graph for postage stamps of 3 rupee.

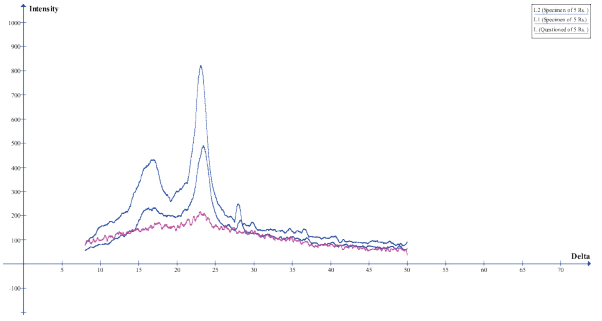

Fig 8: Graph for postage stamps of 5 rupee

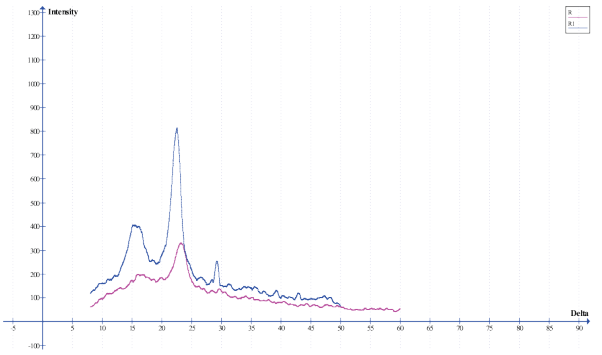

Fig 9: Graph for postage revenue stamp.

In fig 6, 7, 8, 9: the upper two lines that are of purple colour shows the presence of pure cellulose crystalline structure in the specimen postage stamp, as it contains sharp peaks in between, while these peaks are of less intensity in the graph of counterfeited postage stamp shown by lower pink line, hence more amorphous material is present in counterfeited postage stamp. The other smaller peaks which are present on the either side of the larger peak displays the presence of inorganic fillers which are used for the purpose of smoothening of postal stamps but these peaks are absent in the pink graph of fake postal stamps as it does not contain these type materials in it. The graph of original postage stamp shows multiple

peaks in the XRD which are absent in the graph of counterfeited stamps. These multiple peaks occur due to the presence of oxides which are utilized for the manufacturing of original postage stamp and this will not be found in the colour photocopied postage stamp, as they are made up of normal paper.

Conclusion-:

A discrimination procedure for postage stamp samples based XRD was presented. The 4 postage stamps, indistinguishable by visual examination, could be discriminated. This result was achieved by a nondestructive technique, requiring very easy and immediate data treatment. The technique allowed to detect the variations in the structure brought about by different processing parameters, manufacturing conditions and addition of inorganic fillers. With the help of above technique, we can differentiate genuine from counterfeited postage stamps, which have an important application in questioned document examination. The specimen postage stamps shows narrow and multiple peaks as they are made up of oxides and highly purified cellulose material, while all the questioned postage stamp shows broad peaks as they are made up of cellulose but in ample amount as well present more amorphous materials. Hence cellulose crystallinity and inorganic fillers are important domains in paper based documents to differentiate genuine from counterfeited.

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