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PIXE Exploration of Trace Elements by Aerosol Irradiation of the VIZAG Atmosphere

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Abstract: ***PIXE analysis was carried out with various aerosol samples in and around Visakhapatnam city to estimate the level of pollution with regard to the trace elemental concentrations. These experiments were carried out at Institute of Physics, Bhubaneswar, using 3 MV pelletronfacility. Aerosol samples were collected by means of Nuclepore Polycarbonate filter with pore size of 0.4 µm and 47mm diameter. These were mounted in a Millipore (PM10) aerosol standard filter holder. The inlet of the sampler was placed at about 5 m above the ground. The air sampling was done for about 12 hours between 6 AM and 6 PM. In order to standardize the detector, the ^{241}Am source supplied by Bhabha Atomic Research Centre, Mumbai, have been used in the vacuum chamber with Be window. The PIXE spectra regarding the present work are analyzed with non-linear least-squares fitting program GUPIXE 95, which provide net peak areas and associated standard deviations (due to counting statistics etc.) for the x-ray lines in the spectrum. The concentration of 15 trace elements at various sites including Pb, Hg, As, Co, Zn, Cu etc. are compared and discussed.***

Keywords: PIXE, Aerosol, Trace elemental concentrations

I. INTRODUCTION

Aerosols refer to the dispersion of solid or liquid particles of microscopic size in gaseous media, such as dust, smoke or mists. An aerosol can also be defined as a colloidal system in which the dispersion medium is a gas and the dispersed phase is solid or liquid. Recently, the atmospheric aerosols investigations are focused on the fine aerosol [1-3] studies. The concentrations and composition of atmospheric aerosols are important factors in understanding the effects of natural contribution and anthropogenic pollutant sources on the environment. The elemental concentrations of the aerosol particles can be used as signatures
Characterizing air pollution over a given area [4].
Particle Induced X-ray Emission (PIXE) is a powerful analytical technique to estimate trace elemental concentrations. The main advantages of this technique are good detection limits, multi elemental capacity, requirement of small sample quantity etc. In present work the trace element analysis was carried out in a few aerosol samples of Vishakapatnam city. Air pollution studies in Visakhapatnam, Andhra Pradesh are of particular interest as many important industries, like Hindustan Zinc Ltd., Bharat Heavy Plates and Vessels Ltd., Hindustan Petroleum Corporation Ltd., Coromandal Fertilizers Ltd., Hindustan Shipyard, Port Trust and the Steel Plant are located.

II. SAMPLE PREPARATION

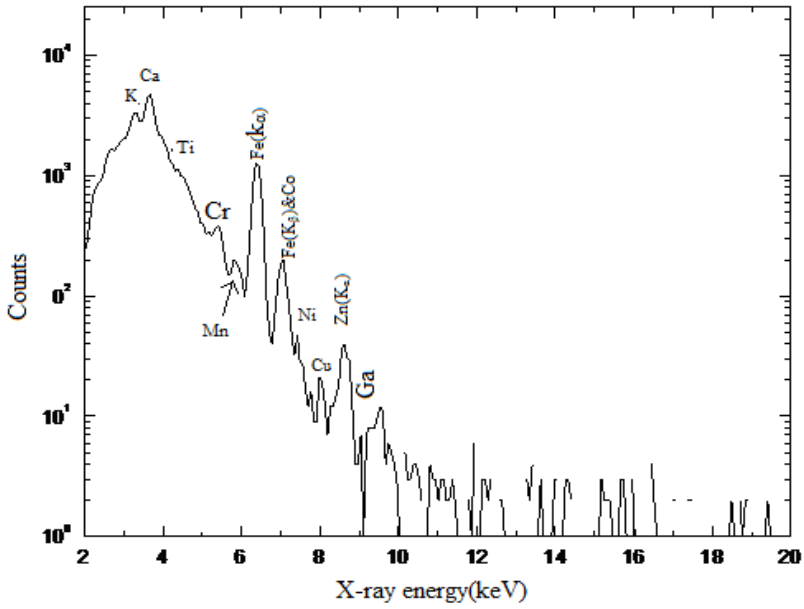
Atmospheric aerosol samples are collected at 7 different sites representing different geographical parts of Visakhapatnam city. Sampling was conducted during the peak periods taking into consideration of local sources (mainly traffic emissions) wind direction and velocity, temperature, humidity and pressure were continuously monitored during sample collection in order to aid the identification pollutants to a maximum extent[5]. The sampling sites are chosen from the following considerations,

A. Regions where the vehicular traffic is high (Railway station).
B. Residential areas near industries (Scindia, Coromandal, Steel plant).
C. Residential areas with heavy population density (MVP colony, Andhra University area, Mudasarlova). Aerosol samples were collected in each case by means of NucleporePolycorbonate filter with pore size of 0.4 µm and 47mm diameter. These were mounted in a Millipore (PM_{10}) aerosol standard filter holder (This holder has an inlet dispersion chamber to produce optimum particle distribution on the surface of the filter). The inlet of the sampler was placed at about 5 m above the ground. The air sampling was done for about 12 hours between 6 AM and 6 PM. The filter paper is weighed before and after the collection of the air sample in each case to know the amount of air particulate matter collected for a particular volume of air. The air through the filter paper was sucked at a flow rate of 15 liters per minute with the help of Millipore diaphragmatic vacuum pump. The

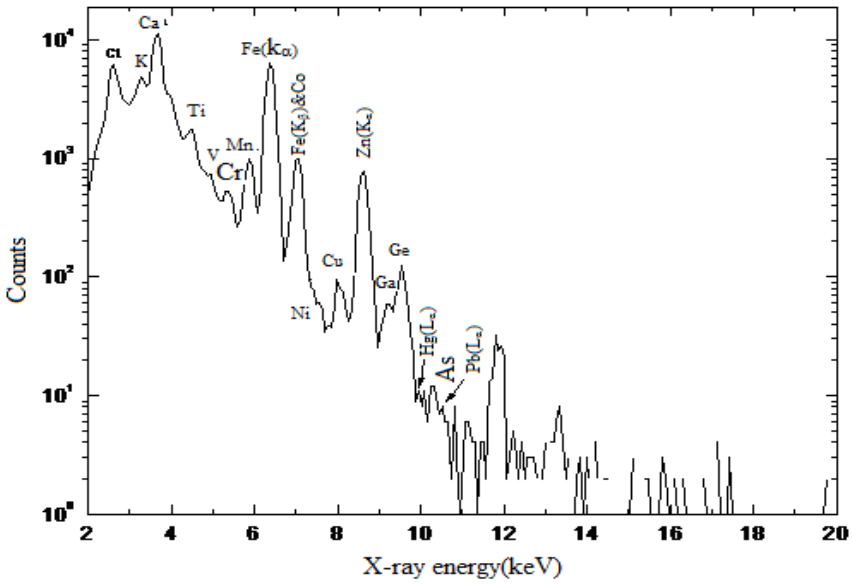
volume flow rate was kept constant by a critical orifice. The flow rate was monitored periodically for each sample with a Rotameter. These samples were preserved in vacuum desiccators to avoid any absorption of moisture.

III. EXPERIMENTAL PROCEDURE

The present experiments were carried out at Institute of Physics, Bhubaneswar using 3 MV pelletron accelerator facilities. The targets thus prepared were excited with a 2 MeV proton beam and the respective X-ray spectra were recorded with a high resolution Si (Li) detector which was kept at an angle of 90^0 to the beam direction [6]. In order to standardize the detector, the ^{241}Am source supplied by Bhabha Atomic Research Centre, Mumbai, have been used in the vacuum chamber with 'Be' window. The typical FWHM resolution of the detector is kept 160eV at 5.96 keV energy i.e for Mn K_α Line [7]. The targets were kept at an angle of 45^0 to the beam direction. The X-ray spectrum of each sample was recorded for sufficiently long time to ensure good statistics [8]. The X-ray spectra of different samples thus obtained are shown in Figures 1 to 7.



Fig[1]: PIXE Spectrum of aerosol sample collected at Railway station area



Fig[2]: PIXE Spectrum of Aerosol sample collected at A.U campus

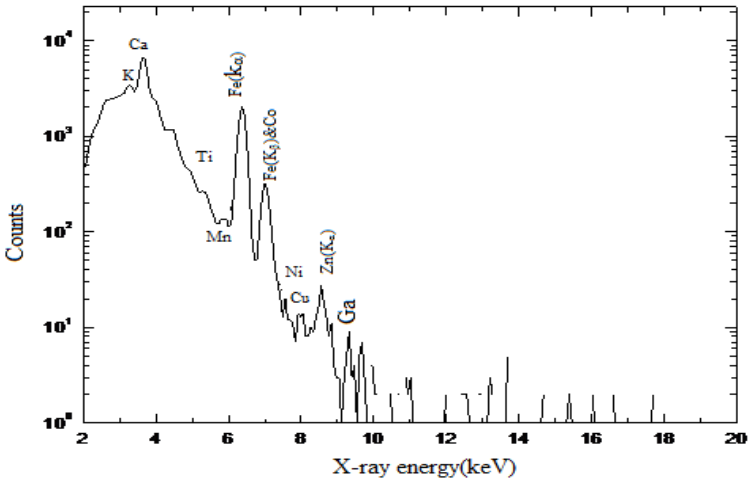
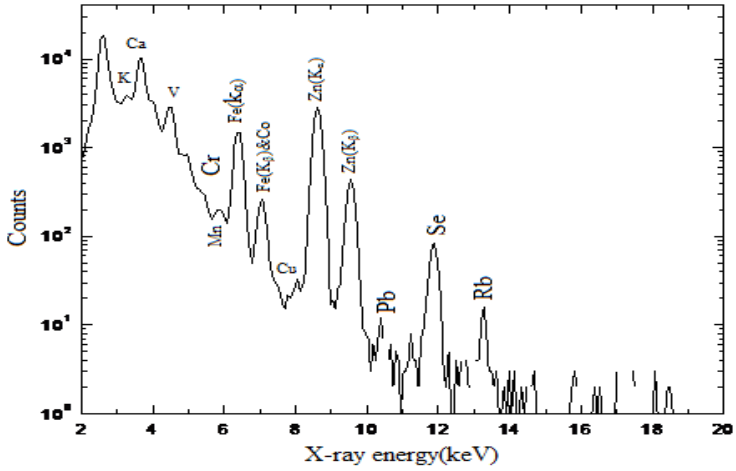
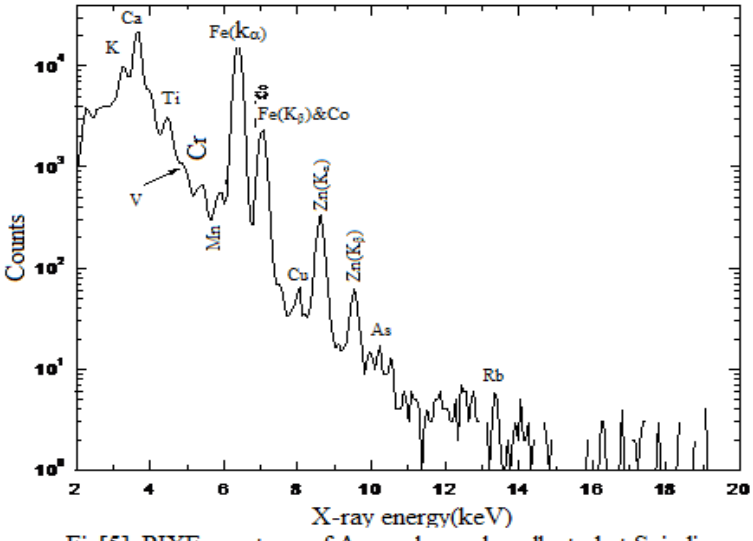


Fig.[3]: PIXE spectrum of Aerosol sample collected at Mudasarlova



Fig[4]: PIXE Spectrum of Aerosol sample collected at MVP Colony



Fig[5]: PIXE spectrum of Aerosol sample collected at Scindia

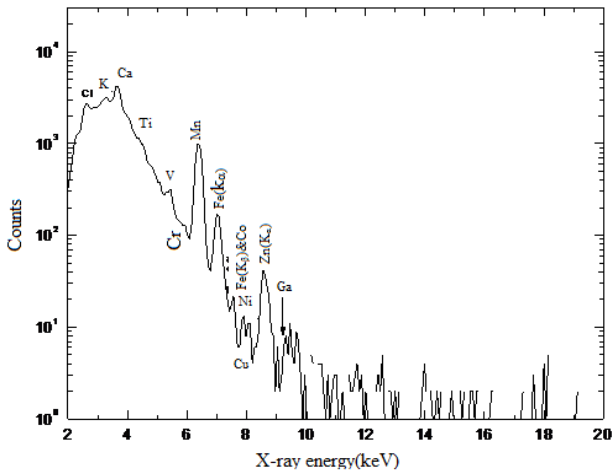


Fig.[6]:PIXE Spectrum of Aerosol sample collected at Coromandal area

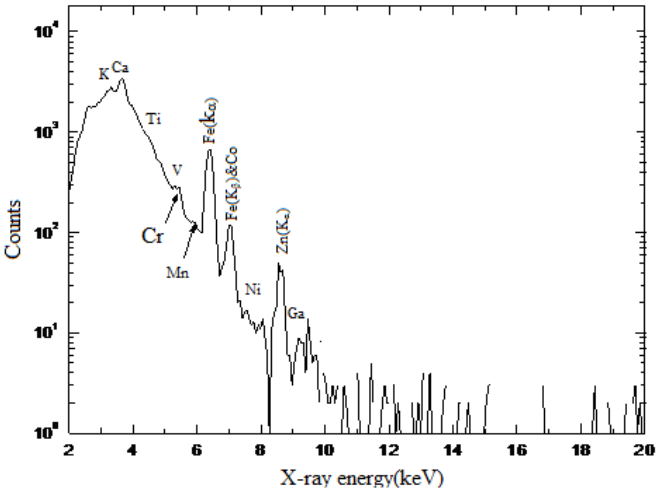


Fig.[7]: PIXE Spectrum of Aerosol sample collected at Steel plant area

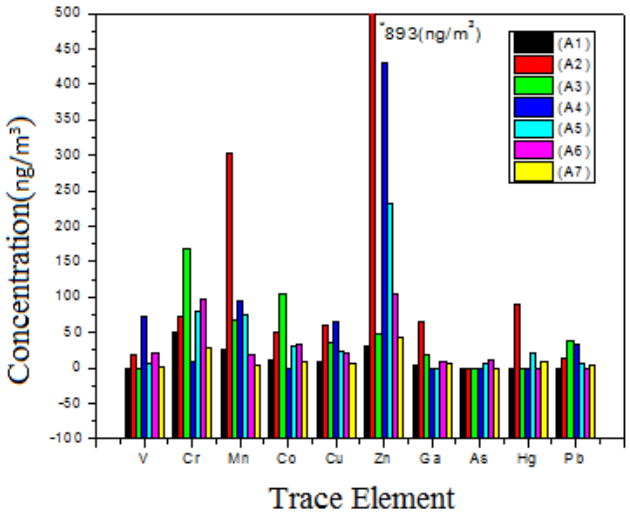


Fig [8]: Comparison of concentration of trace elements at various sites.

IV. DATA ANALYSIS

spectra were analyzed in the early days using AXIL software package. The PIXE spectra regarding the present work are analyzed with non-linear least-squares fitting program GUPIXE [9-11], which provide net peak areas and associated standard deviations (due to counting statistics etc.) for the x-ray lines in the spectrum. In this package, the concentrations are estimated using a standardization technique involving the knowledge of fundamental parameters like, charge that is collected during irradiation for each sample, Area of filter (12.8 cm^2), and Volume of air sucked during the time of sample collection. The concentrations of low Z elements were estimated using the intensities of KX-ray lines while the concentrations of high Z elements were estimated from L X-ray intensities. The concentration of different elements thus obtained due to aerosol samples corresponding to different locations are given in Table [1].

Table: [1] Comparison of trace element concentrations (ng/m^3 ± S.D) in aerosol samples collected from different sites in Visakhapatnam.

Element	Railway station (A1) (ng/m^3)	A.U. Area (A2) (ng/m^3)	Mudasaralova (A3) (ng/m^3)	M.V.P Colony (A4) (ng/m^3)	Scindia (A5) (ng/m^3)	Coromandal (A6) (ng/m^3)	Steel Plant Area (A7) (ng/m^3)
K	375.0±5.2	850.2±7.7	1256±25.8	228.1±55.5	1474±7.81	644±17.9	147.2±5.2
Ca	628.6±4.2	2413±6.5	11487±46.0	97757±22.4	3617±6.5	1659±13.4	344.6±4.0
Ti	16.7±2.3	212.1±3.0	1003.7±28.1	ND	317.8±2.6	3.4±7.5	13.2±2.3
V	ND	18.1±2.5	ND	72.2±2.9	5.2±2.1	21.9±5.7	1.5±1.7
Cr	49.2±1.47	71.5±2.0	167.1±10.9	7.7±3.0	78.8±1.5	95.9±4.5	27.2±1.4
Mn	25.1±1.25	303.5±2.0	67.3±8.5	95.2±3.4	75.7±1.9	17.4±3.8	4.1±1.2
Fe	495.0±2.3	2787±5.8	4716±17.8	664.2±4.5	5215±6.4	1289±6.7	262.3±1.8
Co	11.8±1.5	50.2±4.5	103.2±11.1	ND	30.3±5.7	34.5±4.5	9.1±1.2
Cu	9.7±0.7	61.4±1.8	36.2±3.1	64.5±2.9	22.6±1.1	20.2±2.1	5.5±0.6
Zn	31.7±1.1	893.4±5.1	48.5±4.5	430.1±3.6	232.3±2.3	104.6±3.8	42.5±1.3
Ga	4.1±0.9	64.5±2.9	18.1±3.1	ND	ND	9.4±2.8	5.2±1.0
As	ND	ND	ND	ND	5.9±1.3	11.5±3.1	ND
Hg	ND	90.0±6.9	ND	ND	20.2±4.5	ND	7.6±2.8
Pb	ND	14.3±6.1	36.9±10.5	33.1±9.4	6.9±4.4	ND	2.9±2.9

ND: Non- detectable limit

V. RESULTS AND DISCUSSION

The MVP Colony is the biggest residential colony with high population density. No industries are located in this colony and it is pollution free. This is a very low vehicular traffic zone. However it is very near to shore of Bay of Bengal. The elemental concentration in the air sample of this area is taken as a standard or control sample A4. The elemental concentrations of the aerosol samples collected from the different locations are compared in Table [1].

Vanadium concentration is very high (72.2±2.9 ng/m^3) in MVP Colony but not detected in railway station area and Mudasarlova samples. Natural sources of atmospheric vanadium at MVP Colony include continental dust, marine aerosol, burning of wood, vegetable matter, and solid wastes although contributions from the last three sources may be minimal [12-13].

Chromium concentration is found to be high (167.1±10.9 ng/m^3) in Mudasarlova but very low in Visakhapatnam Steel Plant area. Continental dust flux is the main natural source of chromium in the atmosphere at Mudasarlova. Chromium is released into the atmosphere mainly by anthropogenic stationary point sources, including industrial, commercial, and residential fuel combustion, via the combustion of natural gas, oil, and coal [14].

The concentration of manganese is found to be high (303.5±2.0 ng/m^3) in air sample of Andhra University and very low in Steel Plant sample. The main sources of manganese release to the air are industrial emissions, combustion of fossil fuels, and re-entrainment of manganese-containing soils during construction activities. Recently, the construction activities are intensified around Andhra University and Siripuram areas. So re-entrainment of manganese-containing soils during these activities should be monitored.

The concentration of cobalt is found to be high (103.2±11.1ng/m^3) in air sample of Mudasarlova and very low in Steel plant area sample. The primary anthropogenic sources of cobalt in the atmosphere at Mudasarlova are the burning of fossil fuels and sewage sludge, phosphate fertilizers, processing of cobalt-containing alloys, and industries that use or process cobalt compounds. Small amounts of cobalt are found in coal, crude oils, and oil shale [15-16]. Therefore, burning of these fossil fuels for power generation will emit cobalt into the atmosphere. The concentration of copper is found to be relatively high (64.5±2.9ng/m^3) in air sample of MVP colony even though it is considered as normal one but very low in Steel Plant area sample. Copper is emitted into the air in this region is from nonferrous metal production, industrial applications, copper winding works for the home appliances etc [17-18].

The concentration of zinc is found to be high (430.1±3.6 ng/m^3) in MVP colony but very low in Railway station area. Natural emissions of zinc and its compounds to air at MVP Colony are mainly due to windborne soil particles, biogenic emissions and sea salt sprays, processing of zinc-bearing raw materials brass works, coal and fuel combustion[19-20].

Arsenic is found at two sites namely Scindia and coromondal with minor quantities. These findings may be attributed to the shipyard activities near to these sites. The concentration of mercury is found to be high (90.0±6.9 ng/m^3) in air sample of Andhra University and very low concentration was observed at Scindia and Visakhapatnam Steel Plant. However Hg is not detected at the remaining places. The higher concentration of Hg in A. U. Campus can be attributed to the various chemical and biological research activities and solid waste incineration (e.g., batteries and thermometers etc.)[21-22].

The concentration of lead is found to be high (36.9±10.5 ng/m^3) in air sample of Mudasarlova, close to National High Way (High Traffic Area), but not observed at Railway station and Coromandal areas. Organo-lead vapors are most likely to occur in occupational settings (e.g., gasoline transport and handling operations, gas stations, and parking garages) and high-traffic areas [23].

The comparison of concentrations of various trace elements were shown in Fig.[8]. The trace elements are essential to maintain normal metabolism in human body, but at exceeding certain limits (Frequently called as Threshold Level Values-TLV) they can become toxic [24].To dilute the effect of air pollution in and around Visakhapatnam, it is recommended to cover the conveyer belt of iron ore transport in port area, water sprinkling and to put up screens.

VI. ACKNOWLEDGMENTS

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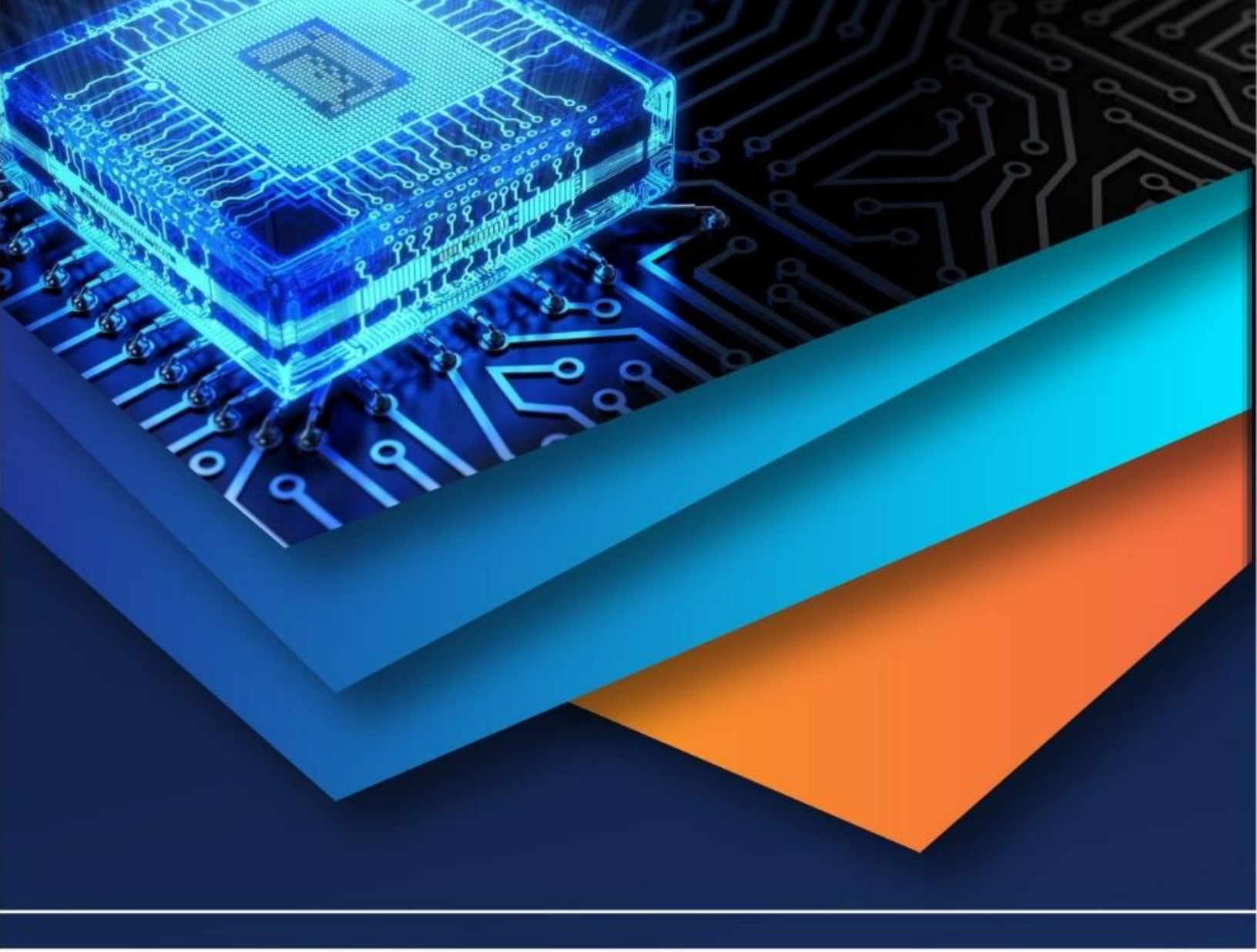

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