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Impact of E-Waste on Human Health and Environment- An Overview

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Abstract: ***E-Waste consists of all waste from electronic and electrical appliances which have reached their end-of-life or no longer fit for their original intended use also recognized as E-Waste and are destined for recovery, recycling or disposal. Discarded computers, televisions, VCRs, stereos, fax machines, electric lamps, cell phones, audio equipment and batteries if improperly disposed they are severely hazardous to the environment. The electronic industry has emerged as world's fastest growing industry in the world. With increase in usage of electrical and electronic equipment, especially in developing countries the amount of e-waste generated each day is growing enormously has emerged as a global environmental issue. This is because the e-waste comprises multiple components some of which contain toxic substances that can have an adverse impact on human health and the environment if not handled properly. The E-waste has become a matter of concern because of toxic and hazardous present in electronic goods and if not properly managed. These equipments are a complicated assembly of thousand materials, many of which contain highly toxic substances such as brominates, toxic gases, toxic metals, biologically active material, acids, plastics and plastic additives. This paper discusses about the severe adverse impacts of the Ewaste on Human health and environment.***

Keywords: e-waste, hazardous, environment, toxic, human health.

I. INTRODUCTION

Electronic waste or e-waste is a popular informal name for electronic devices nearing the end of their useful life. Anything that runs on battery / electricity and completed its life is e-waste. [1] [2].Common electronic products include computers, mobile phones, television sets , refrigerators, VCRs, Audio/stereo equipment, video cameras, wireless devices ,Fax and copy machines ,DVD players, Video game consoles etc., e-wastes are considered to be dangerous, as certain components of electronic products contain hazardous materials that pose a threat to human health and environment . E-toxic components in computers could be summarized as; cathode ray tubes with lead oxide & barium; circuit boards containing heavy metals like lead & cadmium; batteries containing cadmium brominated flame retardants used on printed circuit boards, cables and plastic casing; poly vinyl chloride (PVC) coated copper cables and plastic computer casings that release highly toxic dioxins & furans when burnt to recover valuable metals; mercury switches; mercury in flat screens; poly chlorinated biphenyl's (PCB's) present in older capacitors; transformers; etc. Basel Action Network (BAN) estimates that the 500 million computers in the world contain 2.87 billion kgs of plastics, 716.7 million kgs of lead and 286,700 kgs of mercury. The average 14-inch monitor uses a tube that contains an estimated 2.5 to 4 kgs of lead. The lead can seep into the ground water from landfills thereby contaminating it. If the tube is crushed and burned, it emits toxic fumes into the air[3].

The problem of e-waste has become an immediate and long term concern like any other hazardous waste due to its unregulated accumulation which in turn leads to major environmental problems endangering human health. Advances in the field of science and information technology has revolutionized the way we live, work and communicate bringing countless benefits and wealth to all its users. Due these spectacular developments in modern times have undoubtedly enhanced the quality of our lives. At the same time, these have led to manifold problems including the problem of massive amount of hazardous waste and other wastes generated from electric and electronic products. The creation of new technologies and the globalization of the economy have made a whole range of products available and affordable to the people changing their lifestyles significantly. In the present scenario new electronic products have become an integral part of our daily lives providing us with more comfort, security, easy and faster acquisition and exchange of information. But on the other hand, it is estimated that e-waste is growing almost three times the rate of municipal Solid Waste globally [4]. Not only developed countries but also developing countries like India face the problem of e-waste management. The rapid growth of technology and upgradation of technical innovations in the electronics industry have led to one of the fastest growing waste streams in the world which consist of end of life electrical and electronic equipment products[5],[7].In recent years due to changes in lifestyle affecting consumption and production processes leading to alarming rise in e-waste volumes.

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Optimal and efficient use of natural resources, minimization of waste, development of cleaner products and environmentally sustainable recycling and disposal of waste are some of the issues which need to be addressed by all concerned while ensuring the economic growth and enhancing the quality of life.[6]

II. COMPOSITION OF E-WASTE:

E-waste, also known as electronic waste or waste of electrical and electronic equipment (WEEE), this term is used to describe an electrical and electronic equipment (EEE) that had obsolete or end of life. E-waste has been categorized into three main categories, viz. large household appliances (42%), IT(34%) and consumer electronics (14%).

Washing machine and Refrigerator represent large household appliances, personal computer monitor and laptop represent IT and Telecom, while television represents consumer equipment. Each of these e-waste items has been classified with respect to twenty six common components, which could be found in them.

These components form the "building blocks" of each item and therefore they are readily "identifiable" and "removable". The composition of e-waste is diverse and falls under 'hazardous' and 'non-hazardous' categories. Broadly, it consists of plastics ,ferrous and non-ferrous metals, glass, wood and plywood, printed circuit boards, concrete, rubber, ceramics and other items. Iron and steel constitute about 50% of the waste, followed by plastics (21%), non-ferrous metals (13%) and other constituents. Non-ferrous metals consist of metals like, aluminium ,copper and precious metals like silver, gold, platinum, palladium and so on. The presence of elements like mercury, lead ,cadmium, selenium, arsenic hexavalent chromium, and flame retardants beyond threshold quantities makes e-waste as hazardous waste. It contains over 1000 different substances, many of which are toxic and creates serious pollution upon disposal.

Obsolete computers pose the most significant environmental and health hazard among the e-wastes. On the other hand, e-waste can also be considered as a resource, as it contains many valuable components that actually may be beneficial to recover. For example, it usually contains substantial amounts of copper (often 5-20% by weight), and also relatively high levels of several precious metals, such as silver (0.2%),gold (0.1%) and palladium (0.005%), which originally have been included in the EEE because of their resistant to oxidation and superior conductivity. The toxic compounds that are present in the equipment can cause serious health as well as environmental hazards.

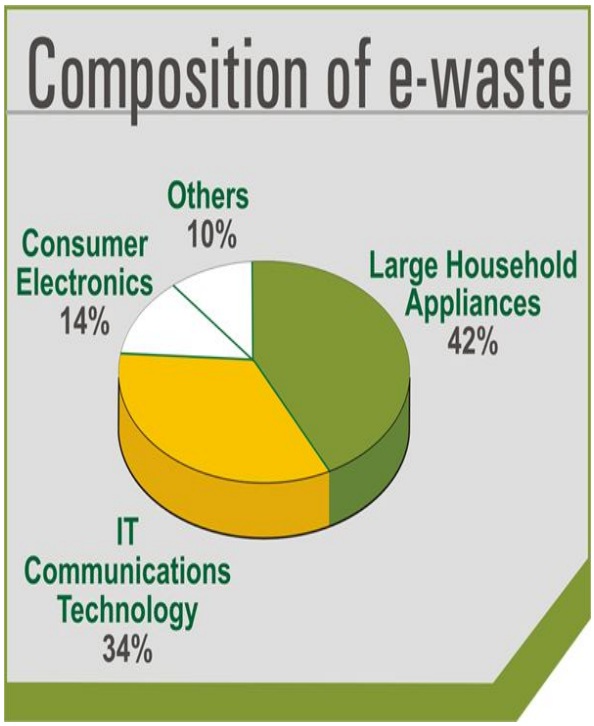


Fig1.Shows composition of E-waste

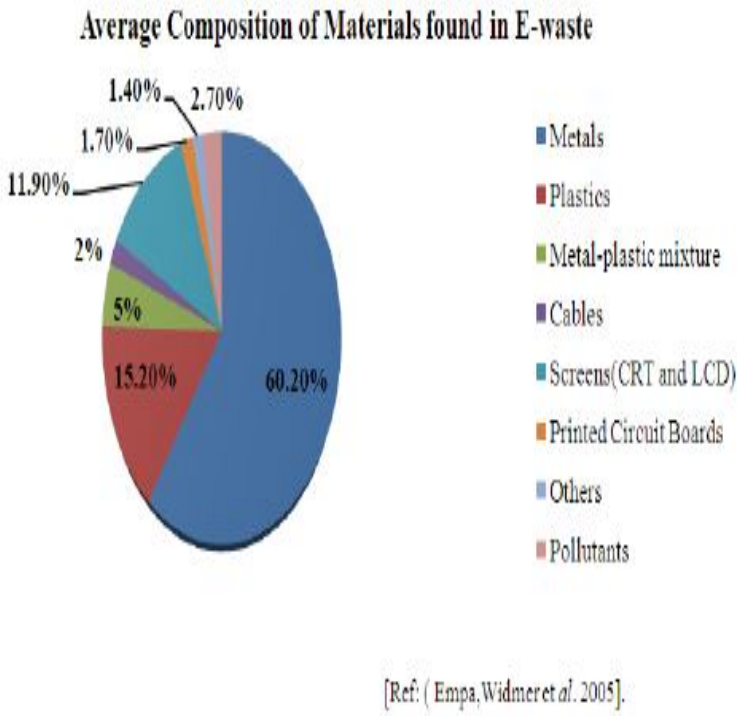
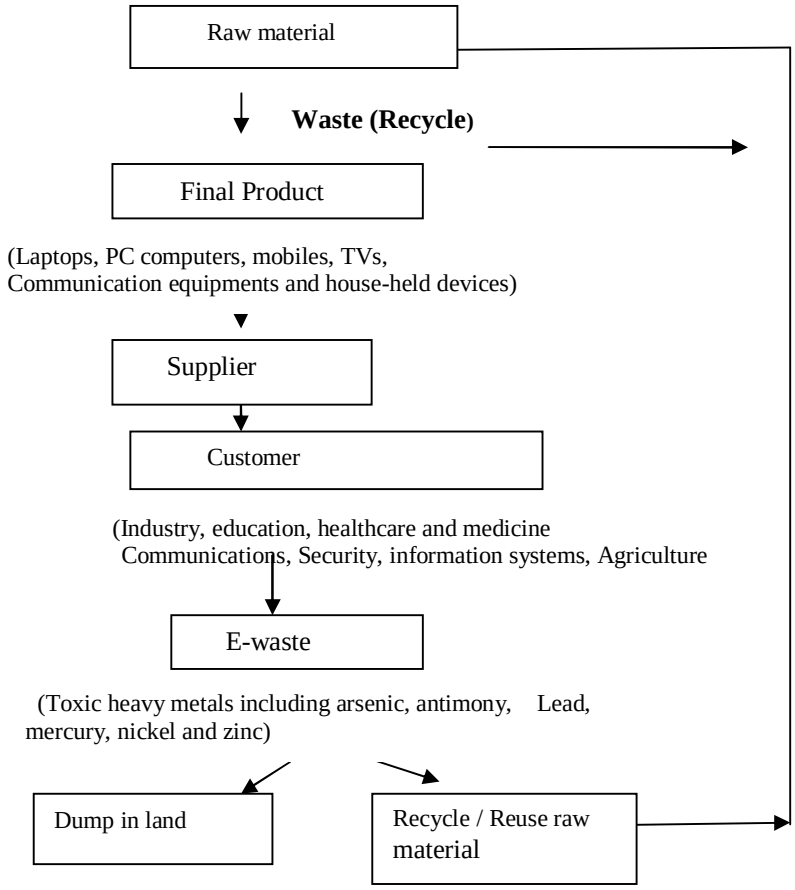


Fig.2 Shows composition of materials found in E-waste

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Flow chart depicting the conversion of Raw material to e-waste



A. Harmful effects of exposure to e-waste:

Even though the harmful effects of e-waste substances is not fully understood, but there is research on the association between e-waste exposure and higher levels of chemicals and metals in human-derived biological samples[8],[13],[14]. Among the various toxic substances found in e-waste heavy metals and halogenated compounds appear to have a major influence on potential health risks[8],[10]

The potential risk of exposure to e -waste have been reviewed recently and include changes in lung function, thyroid function, hormone expression, birth outcomes, childhood growth rates, mental health, cognitive development, cytotoxicity, and genotoxity[11],[12].

The increased exposure to PBDEs from ewaste recycling may lead to interference with the thyroid hormone system and other adverse health effects[14].It was observed that lung function has been decreased in boys aged 8 to 9 years living in an e-waste recycling town but not in boys living in a control town[12]. Lead is also an established neurotoxicant which can damage nervous and reproductive systems. Brominated flame retardants have a long half-life and reportedly lead to impaired learning and memory function ,hormonal ,behavioral and neurotoxic problems. Cadmium tends to bioaccumulate and can be highly toxic, especially to kidneys and bones. Mercury is thought to cause damage to the brain and central nervous system, particularly during early development[16]. It is difficult to quantify the number of harmful substances that humans could be directly or indirectly exposed to e-waste . Even if the concentrations of these substances remains low, the chemicals are often toxic to humans and are still persistent in the environment. There are additional aspects of e-waste exposure which lead to adverse health effects even if daily exposure is low but the cumulative exposure is often high extremely difficult to measure[8,9]. Some of the reagents used in the recycling process would contain cyanide and other strong leaching acids, which may contribute to the hazardous chemical e-waste mixtures. Lead, Mercury, chromium, and brominated flame retardants are likely to cause the most adverse health effects in humans. The landfills are also considered a good source of e-waste through which heavy metals get into the human food chain easily and may cause neurological and bone disorders. Even with the ingestion, inhalation and dermal routes, the heavy metals may cause blood and bone disorders, damage to the neurological and kidney, decline mental capacity. The high concentration of heavy metals can be felt

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in plants, animals, human bodies, water, and air. Due to run off and air transportation the soil concentration changes. The constituents, health effects and sources of constituents are presented in table 1 and table 2 shows environmental impacts due to processing of e-waste most of them being carcinogenic in nature.

Table I: Effects of E-Waste constituents on human health :

Constituent	Source of e-wastes	Adverse Health effects
Lead(Pb)	Solder, CRT monitor glass, lead-acid batteries, some formulations of PVC. A typical 15-inch cathode ray tube may contain 1.5 pounds of lead,[4] but other CRTs have been estimated as having up to 8 pounds of lead.	Adverse effects of lead exposure include impaired cognitive function, behavioral disturbances, attention deficits, hyperactivity, conduct problems, and lower IQ. These effects are most damaging to children whose developing nervous systems are very susceptible to damage caused by lead, cadmium, and mercury.
Cadmium(Cd)	Found in light-sensitive resistors, corrosion-resistant alloys for marine and aviation environments, and nickel-cadmium batteries. The most common form of cadmium is found in Nickel-cadmium rechargeable batteries. These batteries tend to contain between 6 and 18% cadmium. The sale of Nickel-Cadmium batteries has been banned in the European Union except for medical use. When not properly recycled it can leach into the soil, harming microorganisms and disrupting the soil ecosystem. Exposure is caused by proximity to hazardous waste sites and factories and workers in the metal refining industry.	The inhalation of cadmium can cause severe damage to the lungs and is also known to cause kidney damage.[90] Cadmium is also associated with deficits in cognition, learning, behavior, and neuromotor skills in children.
Mercury (Hg)	Found in fluorescent tubes (numerous applications), tilt switches (mechanical doorbells, thermostats), and flat screen monitors.	Health effects include sensory impairment, dermatitis, memory loss, and muscle weakness. Exposure in-utero causes fetal deficits in motor function, attention, and verbal domains. Environmental effects in animals include death, reduced fertility, and slower growth and development.
Hexavalent chromium	Used in metal coatings to protect from corrosion.	A known carcinogen after occupational inhalation exposure. There is also evidence of cytotoxic and genotoxic effects of some chemicals, which have been shown to inhibit cell proliferation, cause cell membrane lesion, cause DNA single-strand breaks, and elevate Reactive Oxygen Species (ROS) levels.
PVC	Cabling and computer housing	Burning produces dioxin. It causes Reproductive and developmental

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		problems; Immune system damage; Interfere with regulatory hormones
Brominated flame retardants (BFR	Brominated flame retardants (BFR) Plastic housing of electronic equipments and circuit boards.	Disrupts endocrine system functions
Barium (Ba)	Front panel of CRTs	Short term exposure causes: Muscle weakness; Damage to heart, liver and spleen.
Beryllium (Be)	Motherboard	Carcinogenic(lung cancer)Inhalation of fumes and dust. Causes chronic beryllium disease or beryllicosis. Skin diseases such as warts.
Copper	Present in copper wires, printed Circuit board tracks	It causes stomach cramps, nausea, liver damage, or Wilson‘s disease.
Nickel	Present in nickel-cadmium rechargeable batteries.	Causes allergy to the skin results dermatitis while allergy to the lung results in asthma.
Lithium	Present in Lithium-ion battery	It can pass into breast milk and may harm a nursing baby.
Americium	The radioactive source in smoke alarms.	It is known to be carcinogenic.
Beryllium	Present in Motherboards.	It is Carcinogenic (lung cancer). The inhalation of fumes and dust causes chronic beryllium disease or beryllicosis.
Sulphur	Found in lead-acid batteries.	Health effects include liver damage, kidney damage, heart damage, eye and throat irritation. When released into the environment, it can create sulphuric acid through sulphur dioxide.

Table 2: The Environmental Impacts Of The Processing Of Different Electronic Waste Components:

e-Waste component	Process Used	Potential Environmental Hazard
CRT (used in TVs, computer monitors, ATM, video cameras, and more)	Breaking and removal of yoke, then dumping	Lead, barium and other heavy metals leaching into the ground water and release of toxic phosphor
Printed circuit board (image behind table – a thin plate on which chips and other electronic components are placed)	De-soldering and removal of computer chips; open burning and acid baths to remove metals after chips are removed.	Air emissions and discharge into rivers of glass dust, tin, lead, brominated dioxin, beryllium cadmium, and mercury
Chips and other gold plated components	Chemical stripping using nitric and hydrochloric acid and burning of chips	heavy metals, brominated flame retardants discharged directly into rivers acidifying fish and flora. Tin and lead contamination of surface and groundwater. Air emissions of brominated dioxins, heavy metals, and PAHs.

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Plastics from printers, keyboards, monitors, etc.	Shredding and low temp melting to be reused	Emissions of brominated dioxins, heavy metals, and hydrocarbons
Computer wires	Open burning and stripping to remove copper	PAHs released into air, water, and soil.

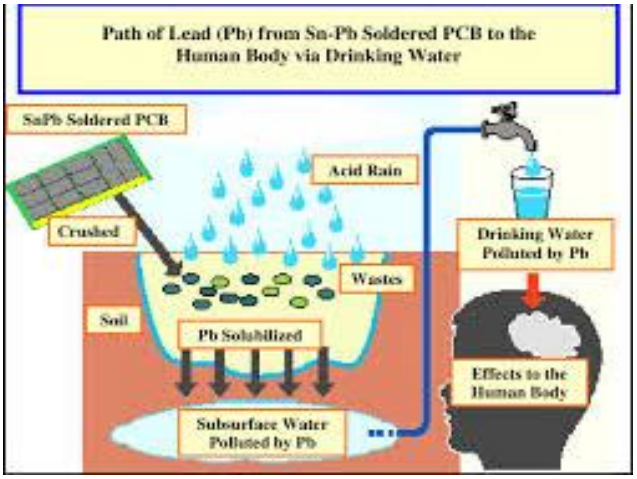


Fig.3 shows toxic effect of lead in drinking water



Fig.4 Adverse effect of burning E-waste

Many of these substances are toxic and carcinogenic -The materials are complex and have been found to be difficult to recycle in an environmentally sustainable manner causing health hazard - The impact is found to be worse in developing countries like India where people engaged in recycling E-Waste are mostly in the unorganised sector, living in close proximity to dumps or landfills of untreated E-Waste and working without any protection or safe guards.

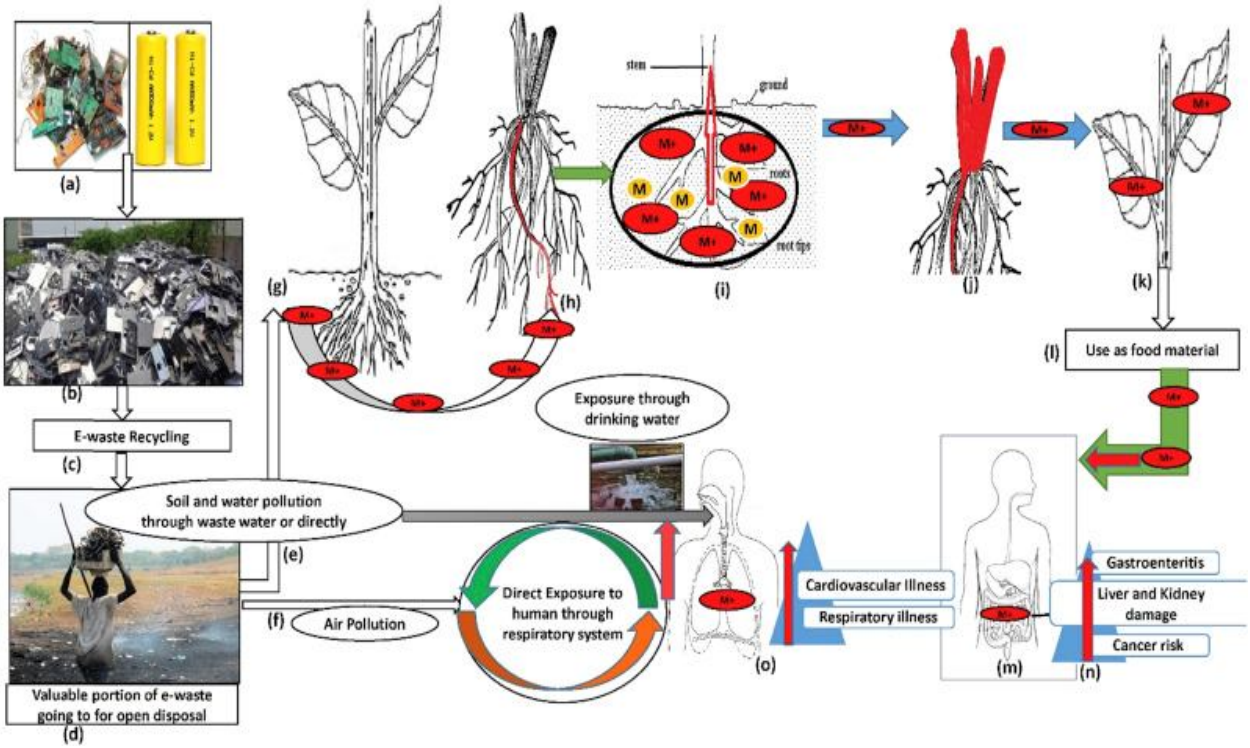


Fig.5 Showing the journey of e-waste from soil to plants through various means causing various adverse health impacts.

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B. E-waste regulation:

Electronic waste or e-waste cause a great impact on environment, therefore, there is a need to curb this menace. The Central Government makes various Acts and Rules for the management and re-use of e-waste such as :

1) Hazardous waste(Management and Handling) Rules, 1989;
2) Bio-Medical Waste (Management and Handling) Rules, 1998;
3) Batteries (Management and Handling) Rules, 2001;
4) Hazardous Wastes (Management, Handling and Trans boundary Movement) Rules, 2008;
5) E-Waste (Management and Handling) Rules, 2011; and
6) E-Waste (Management) Rules, 2016.

Electronic waste or e-waste describes discarded electrical or electronic devices. Used electronics which are destined for reuse, resale, salvage, recycling or disposal are also considered e-waste. Informal processing of e-waste in developing countries can lead to adverse human health effects and environmental pollution.

C. E-Waste (Management) Rules, 2016:

Looking to growing problems of e-waste, the Central Government in the exercise of the powers provided under Sections 6, 8 and 25 of the Environment (Protection) Act, 1986 has notified these rules. E-Waste (Management) Rules, 2016 supersede the E-Waste (Management and Handling) Rules, 2011. It consists of 24 rules divided in Six Chapters and four Schedules. The rules aims to enables the recovery and/or reuse of useful material from e-waste, thereby reducing the hazardous wastes destined for disposal and to ensure the environmentally sound management of all types of waste of electrical and electronic equipment. These rules shall come into force from 1stOctober,2016.

III. CONCLUSIONS

E-waste is a relatively new segment in the global problem of waste removal. It is also the fastest growing segment worldwide in discarded waste. This growing problem in the world is largely ignored or misunderstood. Many people do not understand what it is or how it affects them, the world, or the environment. People either store the obsolete equipment in their home or sell it to the local collectors for monetary benefits. The technology is changing every hour of the day due to availability of new technology due to globalization and replacing the old EEEs in large numbers. The e–waste management has become a complex and poses hazards to the environment in various ways and patients of chronic and acute diseases are increasing exponentially. In 21st century the technology boom will bring ahead more challenges so our preparedness should be equipped with new infrastructure, awareness and technology for e-waste treatment. Many people do not understand that the parts in old devices can be reused in new products. 5Rs (Report, Reduce, Reuse, Recycle and Recover) principles should be followed in the country for the reduction of environmental loading .

IV. ACKNOWLEDGEMENT

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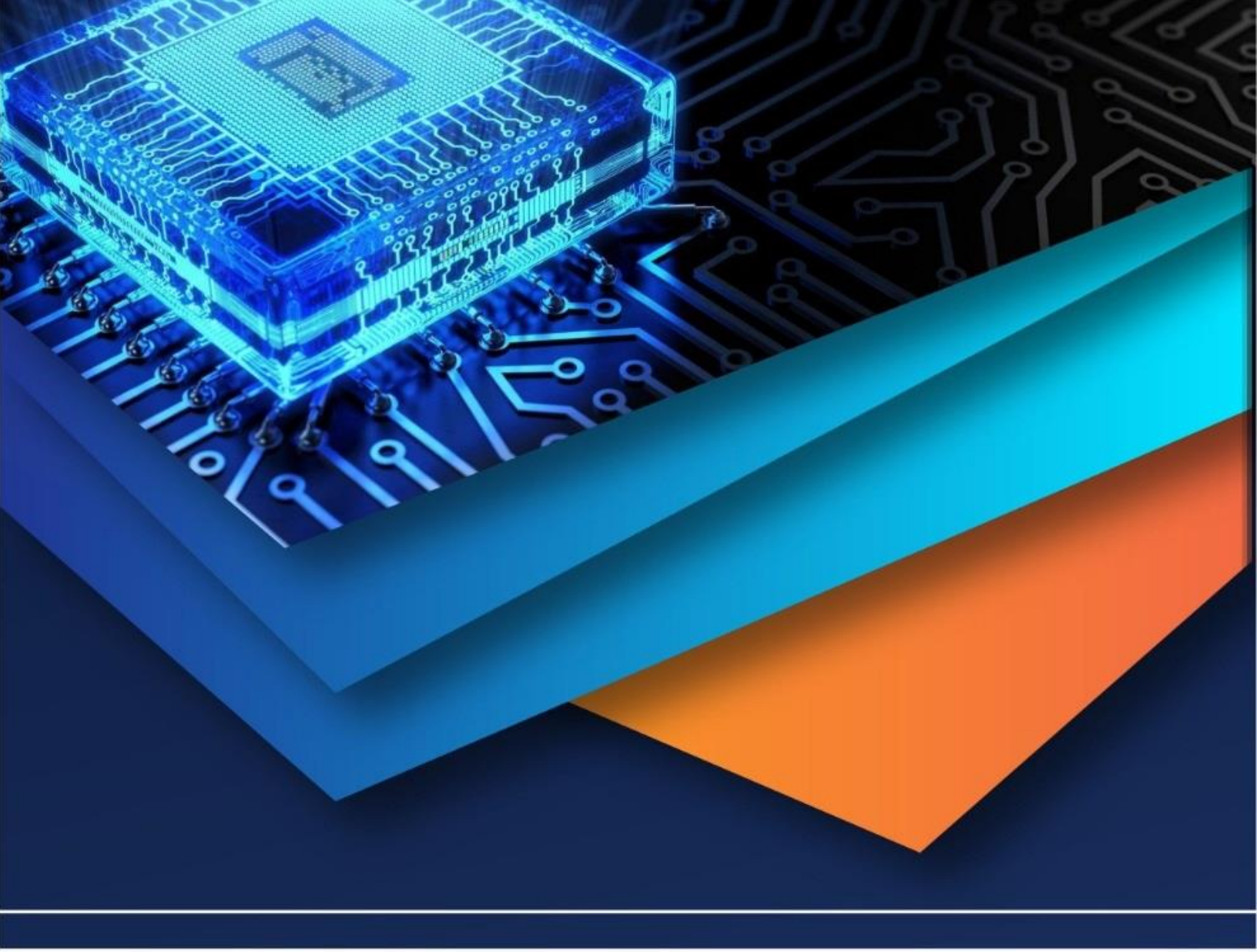
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