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E-Waste and Its Management

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Abstract: ***'E-Waste' is a term generally used for electronic appliances and gadgets which are near or at the end of their useful life. In the midst E-revolution, we change our appliances almost as often as we purchase new attires. Electronic waste or E-waste is one of the fast rising difficulties of the world. Worldwide, the E-waste production is estimated at 20 to 50 million tonne per annum. The rising amount of electronic waste from electronic industries is going to reach calamitous proportions. E-waste comprises of both hazardous and non-hazardous elements as their components. E-waste includes many components; some of these components contain toxic substances that can have an adverse influence on human health and the environment if not handled appropriately. In India, E-waste management assumes greater significance not only due to its own produced E-waste but also because of E-waste discarded by other developed countries in India. In this paper we will discuss about the E-waste, their composition, toxic substances present in E-waste and their harmful effects on the human health and ecosystem. In this paper one can see a picture of poor E-waste management in India. This paper also highlights the need of appropriate management of E-waste and responsibilities and roles of government, producers and consumers to reduce the problem of E-waste so as to save the environment.***

Keywords*: E-waste, E-waste management, Toxic substances, Hazards to human health & environment, Responsibilities and Roles.*

I. INTRODUCTION

A. What Is Electronic Waste Or E- Waste?

Fig 1: E- Waste

Electronic waste or E-waste defines rejected or waste electrical or electronic devices. E-waste is a prevalent, informal designation for electronic goods approaching very near to finish line of their useful life. Used electronics like rejected computers, office electronic tools, entertainment device electronics, cell phones, television sets and refrigerators, which are planned for reuse, resale,

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recycling or dumping are also considered as E-waste shown in fig 1. The term waste is held in reserve for residue or material which is discarded by the consumer rather than reused, including residue from reuse and recycling processes. E-waste is produced when an electronic product is rejected after the end of its useful life. Technically, E-waste is only a subclass of Waste Electrical and Electronic Equipment (WEEE). According to the Organization for Economic Cooperation and Development (OECD), any machine or any device which uses the electric power supply, when approaches to end of its useful life would come under WEEE (EU 2002). Thus E- waste is a term used for the electronic or electric goods that have become undesirable, non-functioning or obsolete and have basically reached the finish line of their useful life. E-waste is not just a waste but also it contains some very poisonous substances such as mercury, lead, cadmium, arsenic etc. These lethal substances can cause cancer, reproductive ailments and many other health harms, if not appropriately managed. Several public policy advocates the term E-waste approximately to all waste electronics. Informal handling of E-waste in developing countries can cause adverse effects on human wellbeing and environment. Electronic scrap machines, such as a computer comprises potentially detrimental chemicals such as lead, cadmium, beryllium, or brominated flame retardants etc. The rapid growth of technology leads to a very large amount of E-waste is created every minute [1]. Reuse and disposal of e-waste may include substantial danger to health of workers and communities in developed countries [2] and excessive attention must be taken to avoid insecure contact in recycling operations and leaking of things such as heavy metals from landfills and incinerator remains [3].

B. Sources of E-Waste

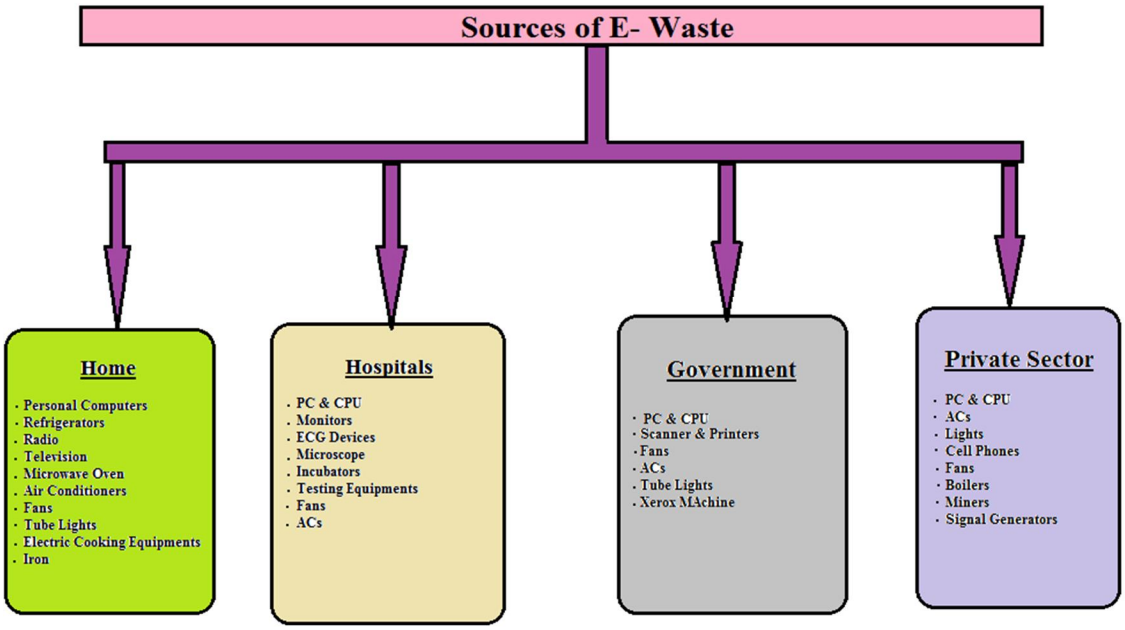

Fig 2: Sources of E- Waste

Actually all humans are the source of this E-waste. As the technology is constantly being modernized with a very fast speed and for all of us to keep up with this quick change we have to keep throwing out the old electronic products and purchasing new products. In today's society it is necessary to have a laptop and phone, this leads to rapid growth of E-waste. Technology has become a need now. We can discuss computers, laptops and phones as examples because these gadgets allow people to connect with the other parts of the world as well as to extend the knowledge. Printers, photocopiers and home equipment are there to make our life easier at the work place as well as home [4]. Some of the products like refrigerators; televisions were once a lifetime purchase. These days it is economical for the people to throw out the damaged appliance and purchase a new one rather than repairing or upgrading old one which leads to 'replace-rather-than-repair' attitude. The accessibility of the latest technology plays a big part in increasing the amount of electronic waste, for example smartphones have dominated society. People are always keen to buy what is latest and the best in the market. This is the reason of a big income for the companies producing electronic and electrical products and this reason motivates such companies to produce more and more which leads to produce a lot of E-waste because old electronic or electric

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products are being thrown out. Contribution of each electronic item in the annual E-waste production 'P' (kg/year), depends upon mass of each electronic item 'M' (kg), their average life cycle 'L' (year), amount of these electronic items available in the market and their consumption 'C' [5].

$$P = \frac{MC}{L}$$

For example personal computers with an average life cycle of 2-3 years contribute to a bigger extent to the total E-waste as compared to any refrigerators or any electrical cook-stoves, having an average life cycle of 9- 10 years. Thus advancement in technologies, changes in style and fashion status are the reasons of increase in E-waste besides the careless nature of people while handling products and short life of some electronic or electric products.

C. Composition of E- Waste

E-waste contains all waste from electronic and electrical machines which have gotten end of their life period and are no longer suitable for their original future use and are intended for salvage, reprocessing or discarding. It comprises computer and its parts (like monitors, printers, keyboards, central processing units), typewriters, mobile phones and chargers, remotes, compact discs, floppies, headphones, batteries, LCD/Plasma TVs, air conditioners, refrigerators and many other household machines. Estimated contribution of different electronic and electric devices in total E-waste is shown below in fig 3.

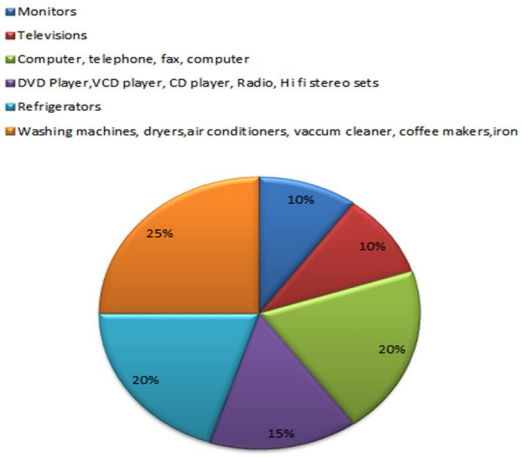

Fig 3: Contribution of different electronic and electric devices in total E- Waste

It is very clear from the studies that most of the E-waste comes from computers, cell phones, TVs, Refrigerators and washing machines. If we know the composition of E-waste then it is easy to find the hazardous component of E-waste and metal retrieval from E-waste. So it is required to know about the composition of E-waste. The observed compositions of personal computer, televisions, refrigerators and cell phones in terms of percentage of its weight are shown below:

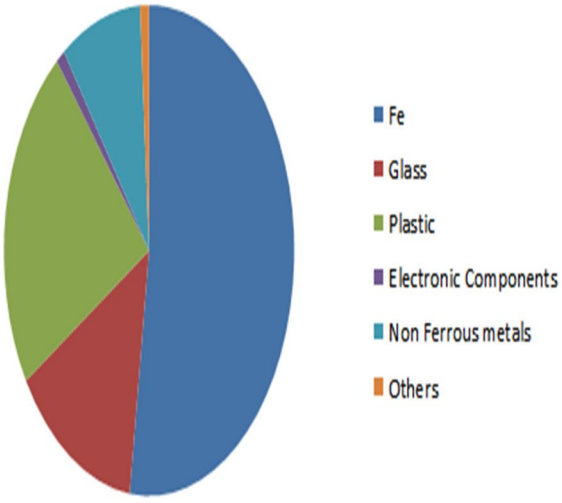

Fig 4: Composition of Personal Computers

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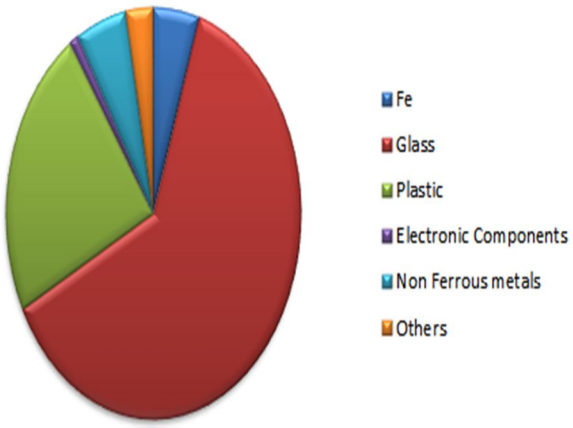

Fig 5: Composition of Televisions

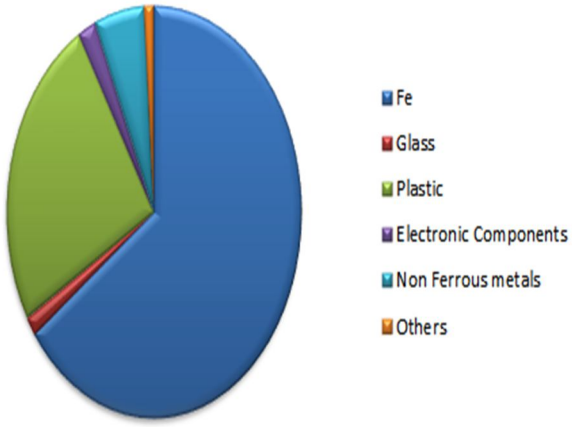

Fig 6: Composition of Refrigerators

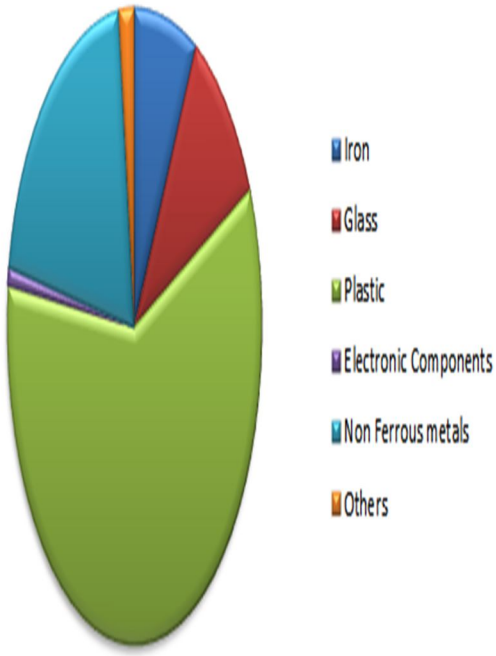

Fig 7: Composition of Cell Phones

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II. TOXIC SUBSTANCES PRESENT IN E- WASTE AND THEIR IMPACT ON HUMAN HEALTH AND ENVIRONMENT

E-waste comprises of more than 1,000 substances, which can be categorized as hazardous and nonhazardous substances. Mainly, it contains ferrous and non-ferrous metals, printed circuit boards, concrete, plastics, glass, wood and plywood, ceramics, rubber and other items. Iron and steel constitute about 50% of the waste, followed by plastics, non-ferrous metals and other components. Non-ferrous metals contain metals like copper, aluminium and valuable metals like silver, gold, platinum, palladium and so on. The presence of many toxic elements like lead, mercury, arsenic, cadmium, chromium and flame retardants beyond threshold limits make E-waste harmful for human health [7] and environment. It contains different substances, many of these substances are lethal, and produce serious pollution upon dumping. Obsolete computers pose the most significant ecological and health hazard among the E-wastes.

A. Some of Toxic Substances That Incudes E-Waste and Their Harmful Effects on Human Health

1) *Cadmium:* It is a potentially long-term cumulative poison and is produced in the environment as powder while crushing and grinding of plastics, cathode ray tubes and electric circuit boards. The most common type of cadmium is found to present in Nickel-Cadmium rechargeable batteries. It is a known carcinogen. The inhalation of cadmium can cause severe harm to the lungs. It can also cause damage to kidneys. Long term exposure to cadmium can cause Itai- Itai disease, which causes severe aching in joints and spine and softening of bones. Cadmium is also related to deficits in cognition, learning, behavior, and neuromotor skills in kids [8].
2) *Lead:* Lead is used for soldering and produced as powder and fumes while mechanical breaking of cathode ray tubes and eliminating solder from microchips. Lead is neurotoxin that affects kidneys and generative system. Lead can affect mental development in kids. Other negative effects of exposure to lead comprises of impaired cognitive function, behavioral disturbances, attention deficits, hyperactivity, conduct problems and lower Intelligence quotient.
3) *Beryllium:* Beryllium is found in switch boards and printed circuit boards. It is used as thermal lubricant. These substances are injurious and can cause infections to lungs. Other common adverse health effects of beryllium are beryllium sensitization, chronic beryllium disease and acute beryllium disease.
4) *Americium:* It is the radioactive source used in smoke alarms and is known to be carcinogenic.
5) *Mercury:* Mercury is released into the environment while breaking of electric circuit boards and switches. It is found in fluorescent tubes, tilt switches like mechanical door bells and flat screen monitors. It can cause sensory impairment, loss to memory, weakness of muscles and dermatitis. Mercury affects the central nervous system, kidneys and immune system of the body. It impairs fetus growth and can harm infants through mother's milk. When inorganic mercury blowouts in the water, it is converted into methylated mercury, which bio-accumulates in living organisms and concentrates through the human food chain through aquatic life, particularly by fish. It can reduce fertility, slower growth and development of animals and even can cause death to animals.
6) *Sulphur:* It is found in lead- acid batteries. It can cause eyes and throat irritation and damage to liver, kidneys and heart. It can produce sulphuric acid when released into the environment.
7) *Chromium:* It is used to guard metal covering and plate in a computer from erosion. Inhaling of hexavalent chromium can be cause of damage to livers and kidneys. It also affects respiratory system and causes asthmatic bronchitis and lung cancer.
8) *Plastics:* Plastics are found in circuit boards, cabinets and cables. Burning PVC which is a component of plastics produces dioxins. Dioxins can harm reproductive and immune systems.

B. Impacts of E- Waste on Environment

E-waste disposal has become a problem. E- waste disposal has invited many environmental risks because of the components which the rejected electronics are made of. The destructive effects of e-waste cannot be inconspicuous. Every year, a cumulative amount of electronic items are being discarded in landfills, which is the cause of growing pollution. The major ways in which e-waste can affect the environment are [9]:

1) *Air Pollution:* Many fundamental processing plants for E-waste management are not safe as they produce air pollution. Many traffickers burn the copper wires in open air to get the valuable copper inside wires. Also, hydrocarbons are released into the air when computer chips are uncovered off their gold plating. These reasons produce the air pollution.

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2) *Water Pollution:* In most part of the world, underground water is not suitable to drink directly. Long time ago, people simply used to pull out water from wells and drink it without any purification treatment. But now, we have to use filters to purify the water and to make it drinkable. It is just one of the many issues and hazards of E-waste. The electronic devices, dead cells and batteries which you throw away with other house waste contain lead that easily blends with underground water and make it unfit for direct drinking. The water gets polluted when Cathode ray tubes present in old monitors of a computer, video cameras and televisions are broken apart to eliminate the yoke and landfill the shell. Lead and barium contained in the shell may cause soil leaching and then leads to contamination of groundwater. This threatens the life of people who use this water and the animals that depend on this water for their nourishment. The rudimentary process of reprocessing of E-waste also leads heavy metals and persistent organic pollutants to collect inside the human body on inhaling the polluted air.
3) *Soil Pollution:* E-waste poor handling also leads to soil pollution. In this way, poisonous heavy metals and elements from E-waste pass in the "soil-crop-food pathway," one of the most important routes for exposure of the human to heavy metals. These toxic elements are not biodegradable—they persist in the environment for very long time which increases the danger of exposure, which leads to very serious health problems.

III. E- WASTE MANAGEMENT

A. What is E- Waste Management?

E-Waste management is the art and science of efficaciously handling the thousands of tonnes of extremely harmful electronic waste increasing day by day. E-Waste is the fastest rising kind of waste in the world. It is a gigantic problem already gaining momentum at a speed that is scary. Yet most of us aren't cognizant about its gravity. These reasons have given rise to the necessity of E-waste management. E-waste management helps to recover and reprocess as much usable material as possible. It confirms that all the energy and water used to create these products is not totally futile. It also scavenges for the rare metals, which are not replenish-able resources. Thus, E-waste management is not only advantageous but important.

B. Why E- Waste Management is indispensable?

Proper discarding of E-waste has become a priority. Many people are not cognizant of the fact that electronic appliances like cell phones and computers actually comprise of many toxic substances that can leach out into the soil and cause harm to the environment. The problem has been increased so much because of the fact that the elements that are used in the fabrication of these electronics are usually quite expensive. Because of this reason, many leading companies often try to pull out these elements from the rejected electronics by using the ways that are unsafe. Heavy metals such as cadmium, lead, and mercury that are part of E-waste pose a great threat to the environment and human health. Most of the users believe that only items like cathode ray tubes need proper dumping. But they don't know that cell phones contain a heavy toxic metal beryllium, which can cause serious harm to the lungs. In addition to the toxins E-waste also contains the elements which take many years to biodegrade, which could mean that landfills with electronic waste could stay like that for centuries. Keeping this situation in mind, various environmental organizations and the government has taken steps to manage E-waste as much as possible. Several nations have approved laws regarding the proper dumping of E-waste. In most of the laws, rejected electronics are barred from being disposed in landfills. According to the law, electronic waste matters can only be discarded in a landfill that is well-found to handle toxic substances. Many companies have started taking proper actions to significantly reduce the amount of E-waste that they produce. Producers of electronic items have started taking products back when they have outlived their usefulness. Producers safely remove elements like copper and other unsafe metals from the electronics and then dispose of the rest of the materials in a safe manner. Such actions need to be taken efficiently in other parts of the world.

IV. E- WASTE MANAGEMENT IN INDIA

India is the fifth largest creator of E-waste in the world. The Basel Action Network (BAN) which works for deterrence of globalization of poisonous chemicals has specified in a report that 50 to 80 % of E-waste collected by the US is transferred to India, China, Pakistan, Taiwan and a number of African countries [10]. This is done because low salaried labor is available for recycling in these countries and in the US, export of E-waste is permitted. The difficulties associated with E-waste in India started developing after the first phase of economic liberalization, after 1990. Due to the very tough competition in the market of brands, quality, price, and facilities accessible between the various Indian and Foreign companies, many electronic industries raised in India. Also, during the post-liberalization epoch, due to economy rate and growth in the purchasing capability of the individuals, there was a big boom

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for the electronic item industries in India, especially for the home appliances, telecommunication, IT and computers. Further, due to infrastructure improvements and e-governance, IT revolution in India is marked by the application of information technology in a big way in all zones. According to UNU reports, in 2014 India has discarded 1.7 million tonnes of electronic and electrical equipment. Through inappropriate methods of E-waste disposal, massive volumes of E-waste is potentially collected by the informal sector that come in direct exposure to toxic substances such as lead, cadmium, chromium. New guidelines came into effect in May 2012, and applied to every manufacturer, buyer involved in the production, sale, and purchase and processing of electrical and electronic devices, as well as collection center of E-waste and recycler of E-waste. These guidelines hold these stakeholders accountable for obeying the stated guidelines and in case of failure to obey the instructed guidelines by the government of India will result in severe penalties. According to a report by the industrial body ASSOCHAM August 2014, augmented use of electronic devices, telecom, information and technology and home appliances have collectively created nearly 13 lakh tonnes of E-waste annually in India. This report has also underlined that Delhi-NCR, Mumbai and the IT capital of India, Bengaluru collectively produces over 2 lakh tons of E-waste per annum. Another report from Markets and Research in January 2015 has estimated that the Indian E-waste market will grow at 26.22% CAGR during 2014-2019. However, a major portion of so much electronic waste being produced in the country is handled by the informal or unorganized sector using improper ways, which cause environmental pollution and health hazards. With the recently imposed "E-waste Management Rules 2016", India has witnessed a renewed attention on the accountability of producers to restrain the production of E-waste through diverse take-back mechanisms. India has set up Producer Responsibility Organization (PRO) and Deposit Refund System (DRS) and other organization with pre-defined goals that the manufacturers will have to achieve. The new amendment made by government aims to channelize E-waste from the informal sector to the formal sector. In order to confirm that E-waste is managed in an environment friendly and responsible manner, the Govt. of India set up the E-waste Rules.

V. UNORGANIZED E-WASTE HANDLING IN INDIA – AN ENVIRONMENTAL THREAT

Majority of the E-waste contains computers, many electrical devices, many home appliances and health equipment. Apart from various poisonous substances like lead, mercury and arsenic, electronic waste also comprises precious substances like gold, silver and rare earth elements. When it comes to handling E-waste, India depends heavily on the informal sector which accounts for over 90 % of the whole E-waste reprocessing industry. Unorganized systems usually employ low salaried labors, including over 4.5 lakh children who are not expert enough to process E-waste. Working situations in these informal E-waste handling setups are austerely dangerous. Salvaging of E-waste in the informal sector using simple and primeval procedures with bare hands and without any facemask, like acid stripping and open air burning releases numerous toxic chemicals like polyvinyl chloride, chlorofluorocarbons, arsenic, nickel and barium into the environment causing medical illnesses like cancer, asthma, bone ailments and brain syndromes.

Most of the global waste is created by the advanced countries. Salvaging of E-waste in western nations is high as compared to emerging countries like India which have copious space to absorb any kind of waste. It is ten times inexpensive for USA to transport E-waste to Asia than reprocessing. According to the reports of ASSOCHAM (Associated Chambers of Commerce and Industry of India), United States of America is at top of the list of nations from which India imports 42% of total E-waste which is followed by China and European Union [11]. Import of E-waste for reprocessing is banned in India. However, according to a survey of MAIT-GTZ around 50,000 tonnes of electronic waste is imported yearly through misdeclarations by firms, which are making India one of the largest yards of E-wste.

VI. RESPONSIBILITIES & ROLES OF GOVERNMENT, INDUSTRIES & CITIZENS

It is imperative to adopt certain management options to handle the bulk E-wastes. Following are some of the suggested management options for the government, manufacturing industries and the public [12].

A. What Should Be the Responsibilities of Government to Reduce the E- Waste?

1) Governments should set up regulatory organizations in each district, which are vested with the responsibilities of coordinating and consolidating the regulatory roles of the various government authorities regarding dangerous E-waste.
2) Governments should be accountable for providing a satisfactory system of laws, controls and administrative processes for harmful waste management. Existing laws concerning disposal of E-waste should be reviewed and refurbished. A comprehensive law is required which provides E-waste regulation, management and proper disposal of unsafe wastes. Such a law should empower the agency to control, manage and regulate the related activities of government sectors. Under this law, the

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agency concerned should be to collect basic statistics of the materials from producers, processors and importers and to maintain a record of these materials (The information should include harmfulness and potential dangerous effects.), to identify harmful substances and industry should test them for adverse health and environmental effects, to control dangers from production, processing, distribution, use and dumping of electronic wastes, to encourage advantageous reuse of E-waste and encouraging commercial activities that use waste and to educate E-waste producers on reuse and recycling options.

3) Governments should apply strict guidelines against dumping of E-waste in the country by outsiders. Where the laws are broken, stringent punishments must be imposed.

4) Governments should enforce strict guidelines and heavy penalties charges on industries, which do not practice waste prevention and recovery in the manufacture facilities.

5) Governments should encourage and support NGOs and other organizations to participate actively in solving the problem of E-waste.

B. What Should Be Responsibility and Role of Industries?

1) Producers of wastes should take responsibility to determine the output characteristics of E-wastes and if unsafe, should provide proper management options.

2) All workers involved in handling E-waste in industries including those at the policy, management, regulatory and operating levels should be properly qualified and skilled. Companies can approve their own policies and rules for management of E-wastes. Producers should use labeled materials for assistance in recycling and standardize components which can be easily disassembled. Producers should create computer machineries and peripherals of biodegradable materials. Producers should look for green packing options.

3) Companies should adopt waste minimization systems, which will make a significant decrease in the amount of E-waste produced and thereby decreasing the negative impact of E-waste on the environment. It is a reverse fabrication system that designs infrastructure to recover and recycle every material confined within E-wastes metals such as lead, copper, aluminum and gold, and various plastics, glass and wire. Researchers have explained that such a closed loop production and recovery system offers a win-win state for everyone, a reduced amount of the earth will be mined for raw ingredients and groundwater will be protected.

4) Producers, distributors and retailers should take the responsibility of recycling and disposal of their own products.

5) Producers of computer monitors, TV sets and other electronic appliances containing harmful materials must be responsible for educating users and the general public regarding the potential danger to public health and the environment because of their products. For this all computer monitors, TV sets and other electronic devices containing harmful materials must be clearly labeled to mention the environmental hazards and proper materials management.

6) Producers should provide contact details such as address, helpline numbers and e-mail Id of distributors and authorized collection centers so that consumers can return used electrical and electronic equipment.

C. What Should Be The Responsibilities of the Consumers?

1) Consumers can donate used electronic items; donating electronics for reuse extends the lives of valuable goods and also keeps them out of the waste management system for a longer time. Care should be taken while donating such products i.e. the products should be in working condition. Reuse of these products also benefits society. By donating the used electronics, many lower-income families can afford to use these devices that they otherwise could not pay for.

2) E-wastes should never be dumped with the other household wastes. This should be separated and sold or donated to various organizations.

3) While buying electronic products consumers can opt for those products which are made with fewer lethal substances, products which uses reprocessed content. Products which are energy efficient. Products which are easy to disassemble. Products which utilizes nominal packaging. Products which offer take back options. Products that have been certified by regulatory authorities.

4) Consumers should opt for upgrading their computers or other electronic items to the modern version rather than purchasing new equipment.

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VII. CONCLUSION

Electronics and electrical devices seem efficient and environment friendly, but there are veiled dangers associated with them once these devices become E-waste. The harmful materials confined in electronics products, coupled with the fast degree at which we're replacing obsolete devices, causes a real threat to human health if these electronics products are not properly treated prior to dumping. The precarious nature of E-waste is one of the rapidly increasing environmental issues of the world. The ever-growing quantity of E-waste connected with the lack of attentiveness and appropriate expertise is deepening the problem. Maximum amount of the electronic waste from the advanced countries ends up in developing countries where the proper regulations are lax. Growth of population and particularly the progress of mega cities are making waste management in India a major problem. The future of E-waste management depends on the efficiency of local government, the operator of recycling services, on the attitude of citizens and on the key role of producers and consumers to shape and develop the public participation. Established infrastructures, including E-waste collection, transportation, handling, storage and dumping need to be established at national and regional levels for the environmentally sound management of E-wastes. Establishment of E-waste collection, exchange and recycling centers should be encouraged in corporation with private industrialists and producers. Criteria for retrieval and discarding of E-wastes should be developed. There should be policies for the E-waste regulation, import and export of E-wastes and facilitation in development of infrastructure. There should be an effective take-back program that provides incentives for manufacturers to design less wasteful products which contain less toxic substances and are easier to disassemble, recycle and reprocess. There should be targets for collection and recycling, impose reporting necessities and include implementation mechanisms and refund schemes to encourage customers to return electronic appliances for collection and recycling.

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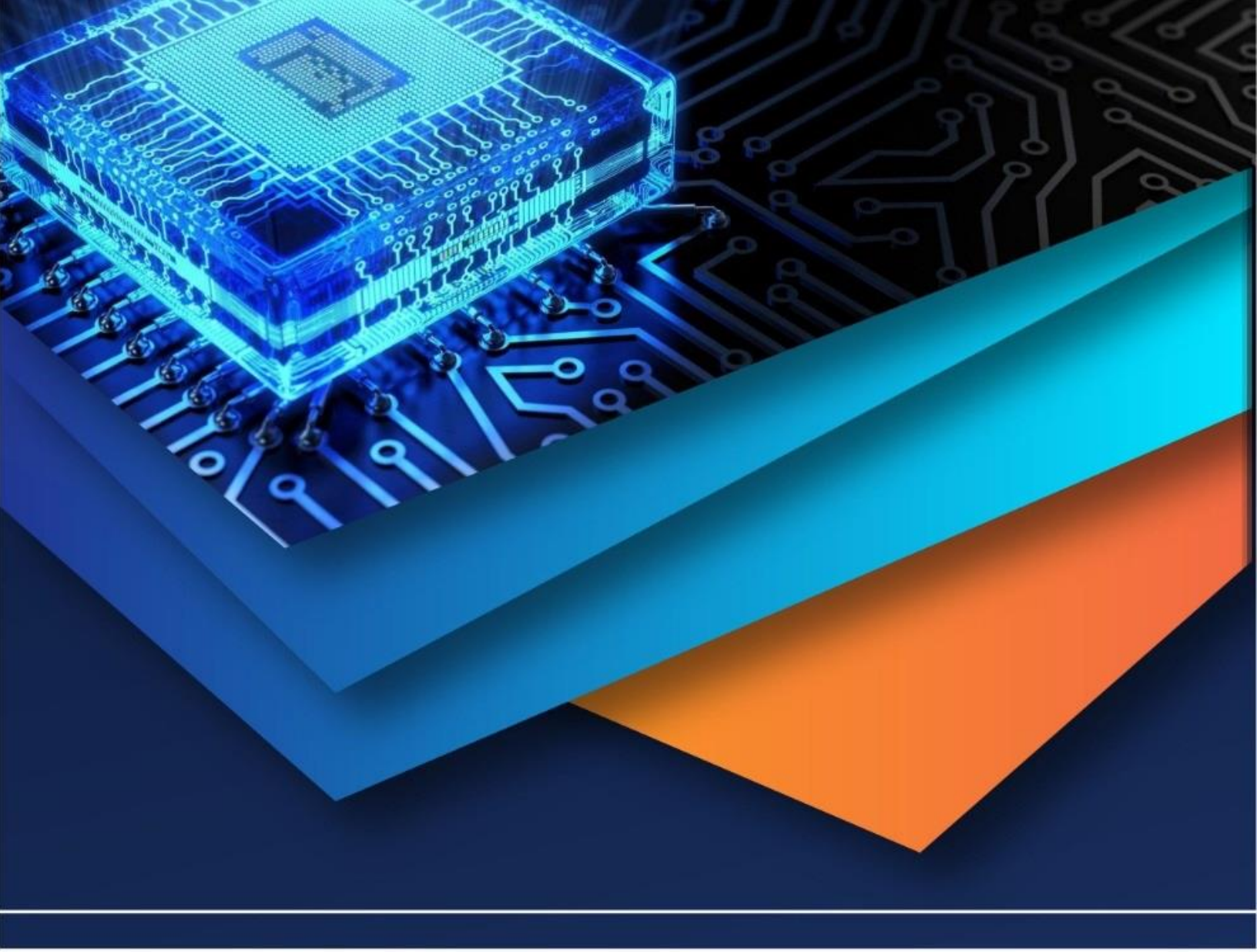

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