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SAFE MANAGEMENT OF E-WASTE DISPOSAL TO PREVENT HARMFUL EFFECTS ON HUMAN HEALTH AND THE ENVIRONMENT

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ABSTRACT

Using electronic devices is a common thing nowadays. Moreover, in the COVID-19 pandemic, all activities must be done from home. Learning, working, and leisure activities are done from home by gadgets. Therefore, electronic device demands are getting higher. E-waste disposal must be a concern for all electronic device users. Lack of awareness on proper management for e-waste disposal may cause harmful effects on human health, plants, soils, and the environment. The effects are increasing the risks of cancers, soil, and environmental pollution. This paper aims to describe the safe management of e-commerce-waste disposal to prevent harmful effects on human health and the environment. Databases from Science Direct, PubMed, and Google Scholar were used. The keywords were disposal AND environment AND e-waste AND health AND management. There were 2170 journals at the beginning. After screening by the title, abstract, and full text, there were 35 journals. Inclusion criteria were full text available, review, and research. Exclusion criteria are opinion and commentary. Reverse logistics is a way to dispose of e-waste by increasing the economic value of the waste. Another alternative to e-waste management is making art and craft from e-waste. Conclusion: Reverse logistics must be taught to people to save the planet from the harmful effects of the unwise management of e-waste disposal. Art and craft from e-waste can be done to increase economic value and reduce hazards to health and the environment. Soil assessment of heavy metal concentration surrounding the waste dump area must be done regularly to prevent bioaccumulation.

ABSTRAK

Menggunakan alat elektronik adalah hal yang umum dewasa ini. Terlebih di masa pandemi COVID-19, semua aktivitas harus dilakukan dari rumah. Belajar, bekerja, dan aktivitas hiburan dilakukan di rumah menggunakan gawai. Oleh karena itu, kebutuhan alat elektronik meningkat. Pembuangan sampah elektronik harus menjadi perhatian bagi semua pengguna alat elektronik. Kurangnya kewaspadaan untuk penanganan sampah elektronik yang tepat akan merugikan kesehatan manusia, tanaman, tanah, dan lingkungan sekitar. Efek yang ditimbulkan adalah peningkatan risiko kanker, pencemaran tanah, dan lingkungan. Tulisan ini bertujuan untuk mengetahui penanganan yang aman untuk pembuangan sampah elektronik demi mencegah efek merugikan bagi kesehatan manusia dan lingkungan. Metode: Literature dicari melalui database Science Direct, PubMed, dan Google Scholar. Kata kunci yang digunakan adalah pembuangan DAN lingkungan DAN sampah elektronik DAN kesehatan DAN penanganan. Ada 2170 literatur di saat awal pencarian. Setelah dilakukan skrining berdasarkan judul, abstrak, dan isi teks secara keseluruhan, maka diperoleh 35 literatur. Kriteria inklusi adalah tersedia teks lengkap, tinjauan pustaka, dan penelitian. Kriteria eksklusi adalah opini dan komentar. Reverse logistics adalah satu cara untuk meningkatkan nilai ekonomis sampah. Alternatif lainnya adalah membuat benda kesenian dari sampah elektronik. Kesimpulan: Reverse logistics harus diajarkan kepada masyarakat untuk menyelamatkan planet dari pembuangan sampah elektronik yang tidak bijaksana. Benda kesenian dari sampah elektronik dapat meningkatkan nilai ekonomi dan mengurangi ancaman bagi kesehatan dan lingkungan. Pengukuran konsentrasi bahan berbahaya pada tanah di sekitar area pembuangan sampah harus dilakukan secara teratur untuk mencegah bioakumulasi.

INTRODUCTION

Using electronic devices is essential nowadays. Moreover, in the COVID-19 pandemic, all activities must be done from home. Learning and working primarily during the COVID-19 cannot be done from home without any gadgets or computers. Therefore, electronic device demands are getting more and more [1)]. The amount of e-waste is predicted to be approximately more than 6 kg per person globally in 2021 [2)]. One electrical device manufacturer can produce many products in a day with different specifications. Consumers like to throw out the old product and change it to newer ones in a short time. This will increase the e-wastes number over and over again [3)]. However, electronic devices have their average life cycle. Those devices must be recycled and well disposed of to prevent further harm to human health, livestock, and the environment [1)].

A high amount of e-waste occurs due to market substitution, increased new products, population growth, and affordability. The lower price of a new product makes people throw away the old one rather than repair it. It is the most common situation in every country. More than 20 million tons of e-waste are found globally [4)]. Computer, ironing, washing machine, freezer, lamp, dishwasher, laptop, printer, telephone, refrigerator, air conditioner, modem, dispenser, handphone, mouse, keyboard, television, monitor, fax machine, scanner, projector, toaster, hairdryer, power supply, cartridge, mp3/mp4 players, headset, earphones, battery, and calculator are electronic devices that most commonly found in the home (domestic), schools, industrial, and offices [1,4–6)]. Electronic device waste is also called e-waste. The collection and disposal must be done safely to prevent unfavorable effects on humans and the environment [1)]. Electronic device waste is found anywhere. It includes at school. Increasing standard of living and school electronic devices enhance the number of electronic device usage and wastes [4)]. Therefore, schools also have to dispose of the e-waste carefully. Moreover, it is associated with risks to children's health when e-waste management is not done correctly. A breastfeeding mother can transmit the heavy metal toxicity to the baby through milk [1,4–6)].

The heavy metals term is not suitable based on scientific reasons. However, the toxic metals term is not commonly used. Heavy metals cannot degrade. They cannot be divided into less toxic compartments. They will accumulate where they are deposited or released. They are non-biodegradable and non-thermal degradable [7)]. Wastes are mainly disposed of improperly in developing countries. They are located in open spaces, roads, and drains. Rainy seasons make water enter the soil. The contaminated water flows as a water source for people. It is a big challenge to be solved by the population and government [6,8)]. E-wastes are also commonly found in electrical/electronic workshops. Therefore, the technicians must master the proper e-waste disposal technique to prevent hazards [9)].

If the e-waste is not well managed, then it will be piled over and over again [10)]. This causes harmful effects on the soil and human health. The harmful effects are increasing risks of cancer, soil, and environmental pollution [8)]. E-waste has economic value. Therefore, reverse logistics must be implemented. Reverse logistics is e-waste management by recycling the waste and delivering the waste to the producer. It is also called a trade-in. It is essential to maintain an economically viable and healthy environment [10)].

Reverse logistics activities support economic flow. E-waste was returned to the manufacturers to gain economic value. This is also called sustainable manufacturing [10]. The government has also realized how to manage e-waste disposal properly to prevent the harmful effects on soil, human health, and the environment. Waste disposal management has to be efficiently managed and organized. Proper waste disposal protects the earth and conserves natural resources [8)]. Another way of e-waste disposal management is by making art and craft from e-waste. This activity will increase the economic value of e-waste while maintaining a healthy environment [3)].

This paper aims to describe the safe management of e-waste disposal to prevent harmful effects on human health and environmental sanitation.

Method

This is a literature review. Databases from Science Direct, PubMed, and Google Scholar were used. The keywords were disposal AND environment AND e-waste AND health AND management. There were 2170 journals at the beginning. After screening by the title, abstract, and full text, there were 35 journals. Inclusion criteria were full text available, review, and research.

Improper open dump system management for solid waste has terrible effects on soil, plants, water, and human health.

Waste is usually thrown away in an open dump. It is the most traditional system. Open dumpsites are the most common found in developing countries. It is preferred because of the low budget. However, this activity caused soil pollution by leachates [11]. Furthermore, streams and rivers might be polluted too. Besides, fish and poultry are contaminated [4,7].

Soil and plants surrounding the waste dumps can be polluted due to badly designed waste disposal facilities [11]. More than 60% of e-waste has heavy metal contents [4]. Heavy metal contents in e-waste might harm soil, plants, water, and human health. There were many contaminants inside the improper e-waste disposal. Contaminants like Cd, Cu, Ni, Pb, and Zn can change the soil content. They have bad impacts on the soil, water, and plants surrounding them. The plants absorb those toxins through their roots. It causes growth retardation and death. If humans consume the plants, there will be many toxic disorders in the kidneys and the liver [11]. Pb is carcinogenesis [12].

There is an area in Hong Kong for illegal e-waste recycling. The water in that area is contaminated by e-waste components. Clean and pure water is difficult to find in that place. The contaminated water is more acidic than normal [9]. Lamp, handphones, audiovisual accessories, television, and the battery can release lead and other chemical substances if they are carelessly thrown into the soil or water. Burying, burning, or throwing those e-wastes together with other domestic wastes can harm the environment and health. E-waste components can be recycled and reused [3]. Product modification, volume reduction (minimization), and reuse can decrease the e-wastes amount [3,13].

Burning e-waste will result in increasing smoke. Smoke contains contaminants such as polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers (PBDEs), heavy metals, and metalloids. Those contaminants cause respiratory diseases and lung and skin cancer [9,14]. Burying e-waste causes increasing concentrations of pollutants in the soil. Therefore, burying and burning are very dangerous for human health and the environment [14]. Heavy metals are divided into four main categories. The categories are essential groups (Cu, Co, Fe, Zn) which are toxic at a very high level; non-essential groups (e.g., Ba, Al, Li); less toxic groups (Sn, Al); and highly toxic groups (e.g., Pb, As, Cd, Hg) which are toxic at low concentrations. Highly toxic groups can cause bioaccumulation. They can damage cell membranes and DNA structures [15].

There was an assessment study of heavy metals in cereals and green vegetables in the Mumbai local market. The Atomic Absorption Spectrophotometer was used to analyze the samples. The results revealed that heavy metal contents were more than the maximum levels. The heavy metals found were Cu, Zn, Ni, and Cd. The atmospheric depositions due to polluted air also caused elevated levels of heavy metals [16]. Heavy metals ingestion through vegetables causes cancerous and non-cancerous lesions in humans. The immunological system was decreased. The fetus had intrauterine growth retardation. Psychosocial behavior showed poor condition. Malnutrition and upper gastrointestinal cancers also occurred [11].

Vegetables mostly grow around dumpsites in rural and urban areas in Ghana. People used to consume the vegetables without knowing the risk of heavy metal contents in the soil and vegetables. Therefore, the soil and irrigation water have to be regularly assessed before planting. It is essential to reduce the hazard risks. The most common heavy metals found were iron, lead, zinc, and cadmium [15,17]. Another study found that heavy metals contamination occurred because the farmer used wastewater for irrigation [18]. The leaching

of heavy metals can go up to 40 meters [17]. However, the water sample collected from a hand-dug shallow well up to 10 km away from the waste dump is polluted [19]. Wastewater used for irrigation purposes was also found in Ethiopia. It caused toxic metals (As, Cd, Cr, Ni) to enter the food chain through edible plants. It increased the risks of cancer [20].

When there is a high contamination level, then the quick remediation strategies (phytoremediation) to decontaminate must be done accordingly [17]. The detailed MPI (Metal Pollution Index) value for each type of vegetable grown in the suspected area is essential for mapping the human health hazards in that area [21]. The hazard risks will be higher for children. A remediation strategy can be done by adding non-toxic materials or mixing them with clean, uncontaminated soils to stabilize the content of the soil. Other methods are ozone oxidation, washing/flushing with surfactants, cyclodextrins, or organic acids [22,23].

Leachate formation and effects on humans and soil in dumpsite area

Leachate is a poisonous chemical formation due to heavy metals waste which commonly happens in open dumpsites. It quickly spreads by rainwater and floods the surrounding area. Leachate has a horrible smell [19]. Leachate poisoned surrounding soils and vegetables. Studies revealed that upstream heavy metal concentrations were higher than downstream due to the leaching process [11,24]. The heavy metal contents tested were lead, mercury, zinc, cadmium, chromium, arsenic, iron, nickel, cobalt, selenium, and copper. Vegetable samples were Telfairia occidentalis, Talinum triangulare, and Amaranthus hybridus. They were collected from an unlined dumpsite in Awka. The study took samples in the rainy season. The heavy metal contents in vegetable samples exceeded the upper limit of WHO/FAO standards. Consumption of polluted vegetables increased the risk of health hazards due to bioaccumulation [11]. Bioaccumulation can occur in soil and the human body [22]. Bioaccumulation is dangerous because it is non-biodegradable, persistent, have a longer half-life, and cycles over in the biological chain for an extended period [16]. Therefore, the reduction of the heavy metals concentration in the dumpsite area must be made to save the population from hazards [11].

Soil is an ideal sample. It stores pollutants for an extended period. Soil pollutants can enter the human body through ingestion. Ingestion can be from consuming polluted vegetables or animals. Animals eat the polluted vegetables, and humans eat the polluted animals. Thus, bioaccumulation occurs. Bioaccumulation is very dangerous to human health because it causes cancer in humans [14].

Heavy metals poison had different effects on the human body. Battery leakage can cause lead contamination [25]. Cadmium was formed in the battery-burning process—high levels of cadmium cause deleterious effects on the kidney, liver, immune, and vascular systems. Cu (copper) poisoning manifested in dermatitis and hair discoloration [11]. Carcinogenic heavy metals are Cd, Cr, and Arsenic.

Meanwhile, Fe, Cu, Zn, Ni, and Mn at a high level can cause toxic effects in humans [16]. Cobalt toxicity causes apoptosis, necrosis, and genotoxicity. Semiconductor content is cadmium. Cd (Cadmium) toxicity increases the risks of getting lung cancer, bone disorder, anemia, and kidney failure. A high dose of Zn can cause respiratory problems, an increased risk of getting prostate cancer, and neuronal deficits [3,22,26]. Lead accumulation can disrupt the nervous system, hematopoietic system, and kidneys. Lead is primarily found in solder. Mercury is found in the lamp and relay. Mercury toxicity causes disorders in the brain, respiration, and skin. Beryllium (Be) toxicity can cause respiratory and skin problems. Be is found in the motherboard of the personal computer. Cathode Ray Tube contains Barium (Ba). Ba toxicity causes muscle weakness, liver, heart, and spleen damage [3]. Therefore, the recycled and e-waste worker's blood must be checked regularly for heavy metals contents also to prevent any toxicity. Soil, plants, foodstuff, and air samples near the waste dumps must be checked regularly to prevent a toxicity circle [14,19].

Challenges in waste disposal management

Several challenges in poor and developing countries in waste disposal management are no plan and coordination of infrastructure. Urbanization and population increase more waste every year [8)]. Less technical managerial skills (illiteracy) and less funding (poverty) for waste disposal management cause poor disposal management [27)]. Bad habits in throwing waste, including improper waste disposal to the surrounding areas for an extended period, cause hazards to health and the environment [8)]. Law, institutional body integration, and comprehensive guidelines must be established to manage those challenges [13)]. Government insensitivity, lack of data, less integrated policy, less technology, and less skillful workers in waste management are challenges in most developing countries [27)].

There are two e-waste management, i.e., the proper and improper types. The proper type uses detoxification, refining, and shredding. Improper management includes burning, chemical washing, and landfilling. Illegal selling in the local market is also improper management [28)].

The regulation about importing e-waste from other countries

Ghana received e-waste from many other countries. Ghana, especially the city of Agbogbloshie, is the most significant digital dumping ground in the world. Ghana became the largest landfill in the world. Other digital dumping grounds are Guiyu (China), Delhi (India), Karachi (Pakistan), and Lagos (Nigeria). The origin of e-waste countries in Europe and The United States [29)].

Indonesia has some regulations for regulating the import of second-hand products. It is the Minister of Trade No. 63/M-DAG/PER/12/2009. Another regulation is the Minister of Trade No. 39/M-DAG/PER/ 9/2009 about the import of Non-Hazardous Wastes. The Decree of the Minister of Industry and Trade No. 520/2003 regulates the prohibition of imports of hazardous waste. Those regulations are essential to prevent the increase of e-waste [4)].

The regulation for e-waste disposal management

B3 stands for *Bahan Beracun dan Berbahaya* (Dangerous and Toxic Materials) [29)]. Based on Government Law number 101 in 2014, it was stated that e-waste disposal management types are reduction, processing, and piling up. Material Recovery Facility is the recommended way based on Environment Ministry number 30 in 2009. The processes are reduction, keeping, collecting, transporting, using, processing, and piling up [30)].

Safe e-waste management

Safe e-waste disposal management can be done by reverse logistics, making the e-waste into art and craft ornaments, also converting e-waste into electric energy. The choice of management depends on funding, skill, resources, and technology [3,10,27,28,30,35)]. All of them are described below.

Reverse logistics

Reverse logistics is essential in managing the rapid increase of e-waste in the population. There are different types of reverse logistics in developing countries. Most of them are in the preliminary step due to a lack of funds, public responses, and informal street waste collectors. The Brazilian law states that waste pickers have an important role in the recycling process. Reverse logistics is essential due to the rapid growth in electronic device usage [10)]. Reverse logistics promotes product recovery and strategies for e-waste management [28)]. Extended Producer Responsibility (EPR) is one of the recycling methods [30)].

Reverse logistics (Reverse Supply Chain/RSC) consists of making a plan, implementing, control of raw materials, inventory, transporting, and products from the point of the consumer to the manufacturer. It is helpful for revalue or proper disposal [10,28)]. The

essential aspects of Reverse Supply Chains are how to implement, evaluate, make a decision, forecast product returns, and design the network [2].

Reverse logistics is the main process in the Reverse Supply Chain. Reverse Supply Chain processes consist of product acquisition (collecting returned products), reverse logistics, inspecting and disposition, repair, redistribution, and sales [2]. The challenges in reverse logistics are shortened life cycle, the emergence of new advanced products, the infrastructure cost to collect and recycle, also comprehensive coordination of government, manufacturers, distributors, retailers (including vendors, businessmen/businesswomen), consumers, waste pickers, and recycling organizations. The government has to monitor the system. The reverse logistics must run safely, smoothly, and efficiently. Protective equipment and control of the environment are needed in the recycling process [6,10,28]. There are 6R concepts to make a friendly environment, i.e., Reduce, Reuse, Recycle, Recover, Redesign, and Remanufacture [2]. Reverse logistics was also implemented in China during the COVID-19 pandemic for handling medical waste [31].

The benefits of reverse logistics are safe internal cost, increasing revenue, and customer satisfaction. The reduced costs are in inventory, waste disposal, and transportation. The waste management processes are refurbishment, remanufacturing, reuse of some essential components, recycling, and recovery. Green processes are done to maintain a safe environment. Reverse logistics extend the product's life. A long-term relationship is built between the customer and the manufacturer. This is one of the excellent marketing steps [28].

Italy implements Reverse Supply Chain. There is the e-waste Collection Centers infrastructure. Local policy measures such as actions, investments, and initiatives are very integrated [32]. Waste pickers have essential roles in the reverse logistic chain. They must be incorporated into an organization and get proper wages. Besides, they must be trained to recycle and pick the waste in safe and healthy ways [10]. Waste pickers and waste disposal workers must wear personal protective equipment to protect themselves from hazardous materials [33]. The wastes must be sorted, weighed, and classified based on their components. The classification is biodegradable and non-biodegradable materials. E-waste is the non-biodegradable portion in most cases [27].

A successful example of reverse logistics is in Sweden. The Swedish producers' organization (El-Krestsen) has an essential role in the chain. This organization leverages the spread of the reverse logistics process. Reverse logistics is useful in increasing income and preserving the environmental [10].

Electronic waste craft

E-waste is increased dramatically in the digital era. In Indonesia, the method of burning e-waste is dangerous due to heavy metal air pollution [3]. Burning can cause the emission of dangerous gases into the air. Thus, air pollution occurs [27]. Burying is dangerous too because the heavy metal contents in the e-waste will pollute the soils. One solution is using e-waste banks. E-waste can be changed into art and craft products based on creativity. The products will increase the economic value of the e-waste. It is safe for the environment. The government supports this program through Small and Medium Enterprises Funding. The e-waste material is sorted based on their physicality and suitability for making the art and craft product [3].

Small and medium-sized enterprises (SMEs) have four strategic steps to assess eco-efficiency. The steps are analysis, identification and evaluation, integration, and action plan. Eco-efficiency measurement is comparing added economic value and added environmental impact. Eco-efficiency measurement also measures environmental costs such as pollution emission and energy used (includes material, water, electricity, etc.) [34].

Converting waste into electric energy

The government in Ghana built an integrated modern factory for waste management in Accra. The factory converts waste into electricity for national requirements. Waste is

transferred to Bioreactor Tunnel. The process is anaerobic. This process can reduce the number of waste and landfills [29].

Another way of converting waste into energy is by making power bank devices from e-waste. An intelligent power bank is created from an old DVD (Digital Versatile Disc) dynamo, USB (Universal Serial Bus) cable, power bank module, an old laptop battery, gear, old fan PCB (Printed Circuit Board), LED (Light Emitting Diode), cable, and converter. It helps reduce the amount of e-waste. Besides, it can save electricity usage at home [35].

Other country's e-waste disposal management program

Japan

Japan has special laws in e-waste management. The law is about practical resource usage. It is used to reduce the waste amount. Producer/manufacturer is responsible for collecting and recycling their waste products. The responsibility includes the funding and infrastructure [3]. Consumers bring e-waste to the shop. Retailers then transfer the waste to the companies [2].

European Union

The European Union has Waste Electronic and Electrical Equipment (WEEE) and Restriction of Hazardous Substances (RoHS). WEEE is important in reusing old products. Meanwhile, the RoHS Directive has an essential role in reducing the dangerous materials in electronics [2].

South Korea

The law of waste recycling management was started in 1992. It is used for protecting the environment through recycling. The waste disposal facility is built in many places to increase the efficiency of waste disposal management. There was a Producer Recycling system in 2003. The producer recycling must determine the amount and performance of the recycling process of the manufacturer. Every manufacturer can do their responsibility in three ways. Those ways are building their recycling factory, outsourcing the recycling work, or joining the Producer Responsibility Organization and funding them [3].

Taiwan

For the first time, Taiwan burnt the non-metal waste and purified the metal part with chemical substances. However, this practice was harmful to the environment. It caused pollution of soils, water, and air. Then, the government established the Environment Protection Administration. Taiwan made a Recycling Fund Management Committee in 1988. This committee is responsible for managing and sorting the waste. Manufacturers and importers have to fund the e-waste recycling process [3]. A summary of the other countries' e-commerce-waste disposal management is shown in table 1.

Table 1.
Other countries' law management for e-waste disposal [2,3]

Country	Law
Japan	Effective resource Usage
European Union	Waste Electronic and Electrical Equipment (WEEE) for reusing old product
	Restriction of Hazardous Substance (RoHS) for reducing the dangerous material in electronics
South Korea	The first law was started in 1992.
	There was a Producer Recycling System in 2003
Taiwan	Recycling Fund Management Committee was founded in 1988 to manage and sort waste.

Planning and policy in waste disposal management

There are some plannings and policies regarding waste disposal management, such as the following [1,8,13]:

a. Giving education to people about proper waste disposal management. Education can be given through formal or informal institutions. Print out and electronic media can be used to raise environmental awareness in the population.
   Convenient benefits from Electrical and Electronic Equipment (EEE) made life easier. Therefore, e-waste has to be handled properly to prevent health and environmental hazards to humans. E-waste is also called Wastes of Electric and Electrical Equipments / WEEE)
b. Sustainable City Programme (SCP) can be implemented to ask for community participation in maintaining a clean and safe environment.
c. Waste management by recycling, reducing, and reuse
d. Funding for waste management from the government
e. Infrastructure development to waste disposal locations must be made easy to access for the population.
f. Comprehensive guideline formulation for duties and procedures.
g. A single body must do integration with the complete instrument and infrastructure.

The recommendation in waste disposal management

Wastes must be sorted out. It is important to differentiate the toxic and non-toxic materials. Toxic materials must be disposed of far away from communities. Valuable materials are reused and recycled. Community awareness is essential to ensure proper waste disposal implementation. Regular sanitation for the environment has to be done at least once a month. Waste proper management campaigns have to be done regularly. Reduce, reuse, and recycle are essential habits to reduce the number of wastes [8]. The rubbish bin has to be divided into some containers and different colors to facilitate the sorting out process. In Jakarta, some special e-waste dustbins are placed in crowded places such as car-free days, apartments, or dormitories. Greenpeace campaign by Ahmad Ashov Berry in 2014 stated that only 16% of e-wastes could be well disposed of. Therefore, the e-waste can be converted into art and craft products such as making animals, fans, or other ornaments from CD (compact disc) or other e-wastes. Those ornaments can be sold to gain economic value [3].

Recycling is the most common method of waste management. It is the same as reusing or changing the waste into a new product. The benefits are reducing waste amount and energy consumption. Air, water, and soil pollution will be less. The greenhouse gas effect is decreased by recycling. Therefore, awareness and educational programs about recycling are needed for all people from young to old [27].

CONCLUSION

There should be monitoring and supervision on e-waste disposal dumpsites to prevent possible heavy metals pollution. Seminars and workshops about e-waste disposal to educate the people must be done. Reverse logistics in e-waste disposal management can prevent harmful effects on human health and environmental sanitation. E-waste imports from developing countries have to be banned to prevent further harm to health and the environment. E-wastes can also be converted into art and craft ornaments. Those ornaments can be sold to gain economic value. Government should support e-waste disposal equipment and management. Recycling, reduction, and reuse must be carefully made in e-waste management to prevent harm and damage to the health and environment. Therefore, constant monitoring of the heavy metal concentration in soil, plants, air, foodstuff, and water near the dumpsite must be done to prevent any possible bioaccumulation.

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