

Urgency of Proper E-Waste Management Plan in Nepal: An Overview

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Abstract

Electrical and electronic gadgets (or E-gadgets) have become indispensable components of our daily life these days. As today's electrical and electronic devices become tomorrow's waste, the potential hazards of these materials in an open environment are significant, as they can contaminate soil, drinking water, air and thus directly affecting human health and surrounding biota. With time, the random disposal of these wastes may lead to a disastrous situation. Although Nepal is one of the least developed countries, also in terms of electrical and electronic equipment, we are importing the high-tech E-gadgets from the developed nations and using them without a proper vision for their after-use management and their impacts on socio-economic values as well as health and environment. It has become an urgent need of the hour to address E-waste challenges taking into consideration the best suited international policies and practices.

Keywords

E-gadget, decomposition, redesign, landfill, incineration

Introduction

According to the International Organization for Standardization (ISO), (2015) electrical and electronic gadgets (also called E-gadgets or E-wastes) are denoted as special wastes designated in the International Classification of Standards (ICS) catalog 13.030.30 (<https://www.iso.org/ics/13.030/x/>). Electrical and electronic devices at the end of their life, generally the old fashioned appliances, not functioning but discarded, are categorized as the E-wastes. Nowadays, in a significant part of the Earth, a person begins his day with the alarm produced by these gadgets and ends with refreshments by watching television. Besides, almost the whole day, people from different walks of life (such

as officers, house-keepers, students, and health professionals use sophisticated E-gadgets to make their work comfortable and efficient. Besides, doctors, engineers, and security experts use the hi-tech E-gadgets for saving lives (Widmera *et al.*, 2005). Thus, these materials on their working periods have become an integral part of human life (DIRECTIVE 2012/19/EU 2012, Narasimha *et al.*, 2019; Sawhney *et al.*, 2008).

The rapid spread of the E-gadgets in every sector of society might ultimately lead to a disastrous situation. It has been estimated that if not properly managed, the E-wastes could bring catastrophic scenarios soon in Nepal (Nepal Telecommunications Authority, 2017). Fig 1 illustrates the general condition of common



Fig. 1. Photographs of E-wastes collection in repair shops of Kathmandu: a) waste circuit boards & cables and b) damaged cell phones & spares of the central processing unit (CPU)

electronic devices in general maintenance shops in Kathmandu. Fig 1(a) shows the electrical/electronic compartments of E-gadgets made up of different types of plastics and metals while Fig 1(b) presents the E-gadgets collected in a repair house. Top of all, cathode ray tube (CRT) disposal is one of the biggest challenges in this field. Therefore, the production of CRT has been almost closed (Musson *et al.*, 2000, Wu *et al.*, 2008).

The E-gadgets comprise two significant units: i) the outer housing of polymer composites, and ii) the inner metallic, conducting-sensory units (Szalatkiewicz 2014, Narasimha *et al.*, 2019). The outer cases and circuit boards are generally made up of polymer resins such as polyethylene (PE), polyvinyl chloride (PVC), polyurethane (PU), and polymethylmethacrylate (PMMA) (Tyagi & Tyagi 2014). The materials are also prepared in the form of composites using different inorganic substances such as silica (SiO_2), calcium oxide (CaO), magnesium oxide (MgO), carbon black, graphite, alumina, etc. as fillers. Nowadays, the organic fillers are also being used due to their lightweight and as a part of green practices (Jarup 2003).

The conducting-sensory units contain various expensive metals, some of them being used to write on circuit board for acquiring unique properties such as gold (Au), platinum (Pt), silver (Ag) and palladium (Pd). The others metals, such as nickel (Ni), tin (Sn), lead (Pb), chromium (Cr), iron (Fe), are inexpensive ones and are employed

for conductivity and soldering purposes (Jarup 2003, Peterson 2009). Moreover, the composites may contain fire retardants, usually made up of hazardous chemicals such as polychlorinated biphenyl (PCB) and polychlorinated terphenyl (PCT). The latter substances exhibit toxic effects on disposal to the free environment (Peterson 2009). Thus, the E-wastes may contain many environments degrading and bio-unfriendly substances such as heavy metals and polymers along with some toxic chemicals which need proper management to save the environment and associated living beings.

This paper aims to shed light on the E-waste problematic and to raise awareness in different strata of society (ranging from manufacturers to consumers and retailers) and to encourage the implementation of so-called 3Rs (reduce, reuse and recycle) strategies as well as redesigning the production pathways.

E-waste Disposal is a Serious Problem It is known that the E-wastes directly pollute soil, underground, and surface water, as well as drinking water and air with metals and degraded microplastics directly affecting the surrounding biota. For instance, CRTs on crashing and burning, release hazardous substances such as lead (Pb), cadmium (Cd), barium (Ba), and fluorescent powders. Polyvinyl chloride (PVC) circuit board produces toxic dioxanes, furans, and degradation products from brominated fire retardants. (Joseph 2007). Concerning human health, there

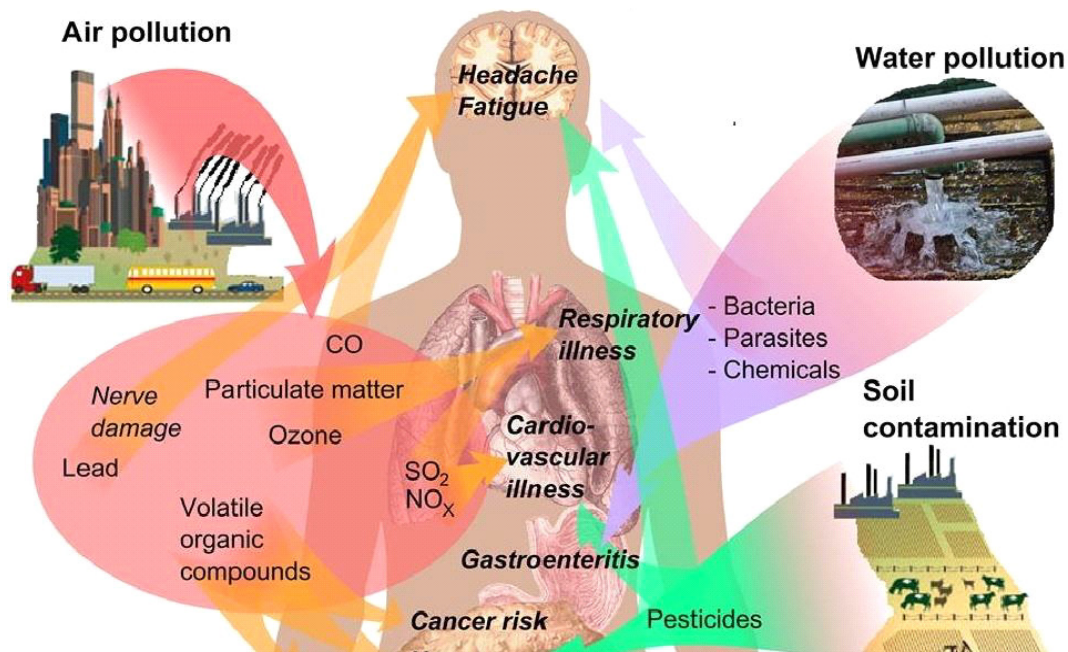


Fig. 2. Schematic diagram showing various effects of E-waste residue left in the soil, water and air to human health (Nepal telecommunications Authority 2017, Terazono *et al.*, 2006)

are many issues reported for the disorder in the brain, lungs, kidney, liver, blood composition. It has been reported that the long term exposure to these substances progressively results in physical, muscular, and neurological degeneration, which ultimately may induce multiple sclerosis, Parkinson’s disease, cancer, reproductive disorder, Alzheimer’s disease, and infertility in humans.

Furthermore, vomiting, fatigue, headache, abdominal pain, diarrhea, appetite loss, and skin irritation (Hiroki 1992) are also associated with the indiscriminate discharge of E-wastes. It has to be noted that the downward diffusion of water under the soil is the most dangerous pollution disseminator and spread the contaminants in all territories. As a consequence, the ground gets infertile on a significant deposition of toxic metal ions (Oppelt 1987). In the same manner, gases produced by incineration of solid E-wastes also pollute the air with poisonous gases, which may be responsible for causing respiratory problems, ultimately leading to lung cancer and other diseases (Dreher & Pulver 2008).

Various types of wastes and resulting pollution of natural environment and their effects on human

health are depicted in Fig. 2. Besides, it is clearly shown how the natural resources like soil, water, and air get polluted by the anthropogenic activities (Terazono *et al.*, 2006, Musson *et al.*, 2000, Premalatha *et al.*, 2014).

International Practices of E-wastes Disposal

There are stringent international practices in sound E-Waste management (Sawhney *et al.*, 2008, Hoornweq & Tata 2012). The most economically developed regions, like the EU, USA, and Japan, have adopted quite strong regulations and policies for E-waste management (Sawhney *et al.*, 2008; Ababio 2012). Also, the economically emerging countries such as India and China have induced E-waste management in their national development policies (Joseph 2007; Chen *et al.*, 2015; Karmacharya *et al.*, 2015).

The global practice of waste management is “no throwing away” where system follows the procedure with a reduction in waste generation, their vehicular collection, separation, reuse, recycle, and finally the waste disposal by composting, incineration and landfilling (Hoornweq & Tata 2012; Narasimha *et al.*, 2019). India added recovery of metals such as copper from the circuit board on its management elements (Joseph 2007). Malaysia practices household

management for E-waste in different ways such as recycling, giving to scrap collectors, dismantling for further applications, and selling as second-hand equipment (Kalana 2010). European Union has formulated quite strict regulatory provisions for the E-waste management (EEC No. 259/93; Directive 2002/96/EC & Directive 2002/95/EC). The Directive 2002/95/EC is about the restriction of use of certain hazardous substances in electrical and electronic equipment. In contrast, the Directive 2002/96/EC limits the use of six harmful substances (such as lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), and polybrominated diphenyl ethers (PBDE)) in E-gadgets (Wu *et al.*, 2008; Mansfield 2013). The restriction of these hazardous substances in E-gadgets automatically has set a standard for production in the EU, preventing many products from being sold in the European territory that contains any of those dangerous substances (The European Communities 2003; Sawhney *et al.*, 2008).

Moreover, Directive 2002/95/EC focuses on the production and dumping of E-gadgets. EU produces more E-waste in comparison to the USA, as the EU has a more dense human population. Both the USA and EU have opposed the E-wastes imports, but they have favored policies to send disposing such toxic wastes to developing countries, unfortunately (Sawhney *et al.*, 2008; Mansfield 2013).

To address these challenges, the principle of 3R's (viz. Reduce, Reuse, and Recycle) is being practiced. Even a new concept for redesigning the industrial manufacturing processes have also been started (Joseph 2007; Sawhney *et al.*, 2008; Ababio 2012; Hoornweq & Tata 2012, Parajuly *et al.*, 2017). Many countries are practicing 3Rs principles to address the E-waste problem. China has adopted a national policy of converting the wastes to energy. (Xu *et al.*, 2016). Utilizing this 'waste-to-energy' strategy, in 2014, China increased its energy production from the wastes by 39 % more than in 2013, and it contributes to the total energy consumption of the whole country by 0.44 % (Dunne *et al.*, 2008). Ireland has a unique waste management policy in which the polluters have to pay. This way, the country has added a 15 % tax more in the purchase of such materials, which, however, has caused a reduction in buying tendency to 92 % (Zaman 2013). The astonishing

results were observed in San Francisco, the USA, where in 2000 the waste was reduced to 50 %, in 2011 80 %, and they have targeted up to 100 % waste reduction (or zero waste planning) by 2020 (Brandl 2001). Such practices are being implemented in Italy, Nova Scotia-Canada, and many other countries.

There are many research works ongoing to overcome the terror created by E-wastes. Different methodologies of chemical and biological treatments for such wastes are being investigated. For instance, it has been reported that metal poisoning can be reduced by leaching with acids and incubation with some bacteria or fungi. The bacteria such as *Thiobacillus thiooxidans*, *T. ferrooxidans* and fungi such as *Aspergillus niger*, *Penicillium simplicissimum* feed on severe health hazardous, soil or water contaminants such as Zinc (Zn), Copper (Cu), Nickel (Ni), Iron (Fe), Lead (Pb), Aluminium (Al) (Widmera *et al.*, 2005; PACE Nepal Pvt. Ltd., 2017).

Electronic wastes, in recent days, have become much more the topic of public and academic concern in the context of growing risks and hazards towards the wellbeing of humans as well as the adverse effect that can be expected for other living beings and environmental balance. The case studies highlighting the status of e-waste management strategies, including standard international practices and regulations adopted in different regions of the world, have been addressed in a recent monograph (Narasimha *et al.*, 2019).

Also based on the experiences of several studies, it has been reported in a recent survey that the consumers are more interested in purchasing brand-new though low quality but cheaply priced electronic devices which are further instead stored due to lack of suitable disposal option (Zeng *et al.*, 2017a, Nnorom *et al.*, 2019).

The equipment discarded to a landfill, though a small amount, begins a new pain cycle by exposing the workers to toxic substances while processing the e-wastes in informal ways (Shaikh *et al.*, 2020). Thus, for the sustainable management of the e-wastes, adoption of the eco-design and industrial ecology as well as 'repair-reuse-remanufacture' approaches, life cycle assessment, and innovative methods for

the conversion of wastes into useful products including elemental recovery and targeting to new materials and energy (Chen *et al.*, 2018; Mihai 2019; Kaya 2016). These efforts have stressed global action, including inaction of regulations, particularly avoiding the toxic materials entering the downstream and recycling and use of green stuff (Zeng *et al.*, 2017a, Zeng *et al.*, 2017b).

report published by the Ministry of Science, Technology, showed Nepal imports 250,000 television sets and 300,000 computers every year, which, illustrates that of course, adds to our E-waste dump after a decade. The survey shows further that Nepal has 40,000 tons of lead-acid batteries used to supply power in the electronics equipment, which could bring catastrophic disaster

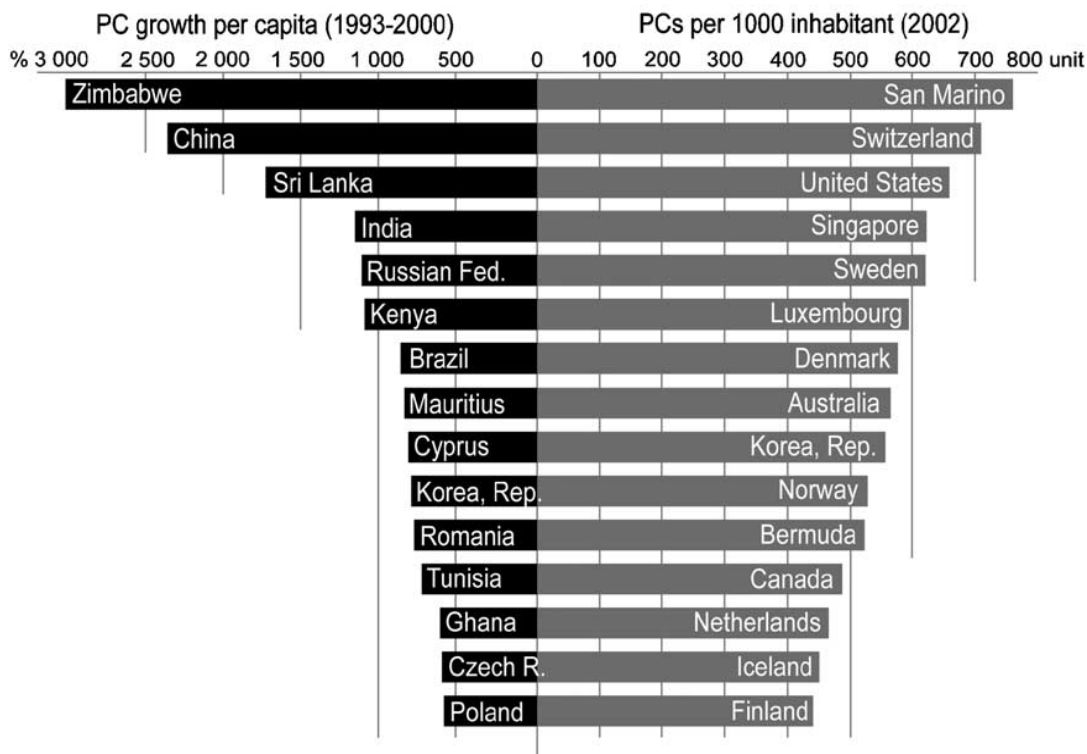


Fig. 3. Statistics for the personnel computer consumption in different countries to correlate E-waste generation (Widmera *et al.*, 2005)

E-wastes Challenges and Opportunities

Today’s E-gadget is tomorrow’s waste. Therefore, E-waste production data can be articulated with the import or consumption of E-gadgets. The drastically increasing international trend of growing consumption is depicted in Fig 3. It shows a tremendously large volume of use of personal computers and smart devices in developed countries in comparison to developing and less developed countries.

In the parallel pattern, the study for television import in Nepal from 1999 to 2011 was found to increase by 58.12 % (Mansfield 2013). The recent

if disposed of in the land or water of Nepal (Pace Nepal Pvt. Ltd., 2017).

Nepal does not have a separate Act for E-wastes management to date. The E-wastes are collected along with other solid waste materials. In 2011 Nepal Government introduced regulation for a solution, E-waste Management (Solid Waste Management Act 2011), for all types of waste including industrial, domestic, medical, chemical, and E-wastes, which are unfortunately not being strictly implemented by concerned authorities (IPE Global Private Limited 2012). An earlier study showed that looking at a per-capita generation of solid waste, waste production is higher in the hilly

region in comparison to tarai and mountains. Fig 4 (a) indicates that with urbanization, the creation of waste becomes higher as expected. The data clarifies that one person generates 283 g of solid waste per day. In the Nepalese society general concept of family members is 5, so with this figure, one can easily articulate that a family produces 1kg of solid waste in a day (Asian Development Bank 2013). A recent study further shows that only the Kathmandu valley produces 700 metric tons of solid wastes every day (Basnet 2014). Generally, the solid waste contains a majority of organic wastes 65 %, which can be easily composted; and the other inorganic wastes are less in composition. Fig 4(b) shows that the plastic waste fraction is 8 %, with metals contribution in total solid waste to 1.2 %, which primarily comes from E-waste

real stakeholders of E-wastes in Nepal are the producers, household users, business houses, institutions, and electronic repair shops, which may have 50 % or more E-waste stocks composed of the total stock of E-gadgets. The scavengers scrap hawkers, and scrap dealers collect all these E-wastes from the consumers. Similarly, the municipality is also one of the stakeholders for an authoritative action plan for waste disposal (Parajuly 2017).

In urban cities of Nepal, the waste disposal practice of household consumers is supported by the municipality. It collects all the wastes from different localities, in an entirely unplanned way and dumps for landfilling. For instance, Kathmandu Metropolitan City (KMC) authority

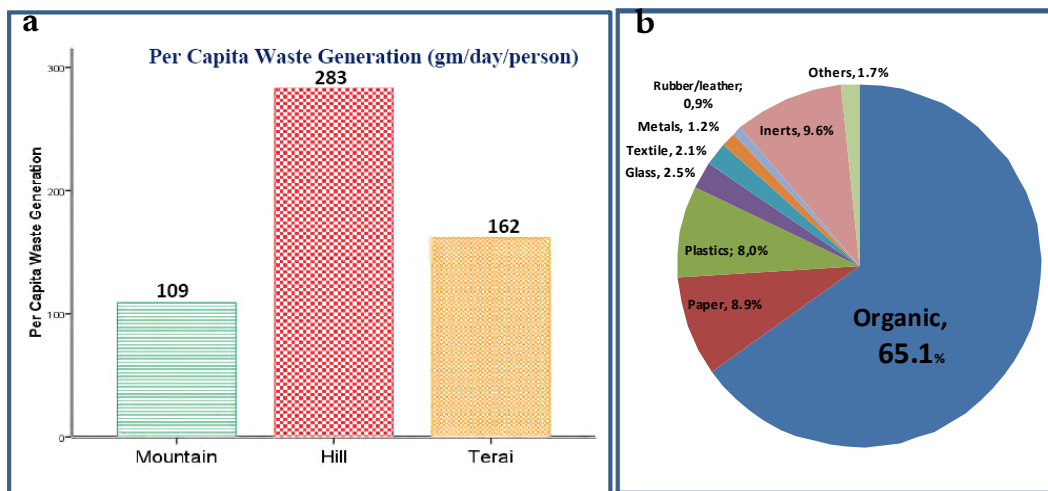


Fig. 4. (a) Plots for per capita waste generation in the Kathmandu valley. (b) Percentage distribution of different kinds of solid wastes disposed of in Kathmandu (Asian Development Bank 2013, PACE Nepal Pvt. Ltd. 2017)

(Asian Development Bank 2013, PACE Nepal Pvt. Ltd. 2017). The data on E-wastes makes it evident that in total, E-waste 21 % is plastic, 50 % is iron with steel, and 3 % is other rare and expensive metals (Asian Development Bank 2013, PACE Nepal Pvt. Ltd. 2017). The proper management of E-waste followed with the recovery of these metals would introduce many opportunities to convert waste to resources.

Nepal's Practice for E-waste Disposal

Depending on the types of stakeholders who generate E-wastes, disposal practice varies. The

collects all solid waste with the help of staff and vehicles from all the houses in a site selected in Kathmandu, Teku, shown in Fig 5. The solid wastes collected in Teku by KMC authority are subsequently transported to Okharpauwa, Sisdol landfill site, without further separation or detoxification. Scavengers make a selection of some of the valued things from the collected wastes and sell to scrap dealers.

During the manufacturing of E-gadgets, some default samples are produced, which are also E-wastes. Likewise, business houses, offices, institutions also generate E-wastes in large



Fig. 5. Photograph showing solid waste collection site in Teku, Kathmandu

quantities after their full utilities with the advancement of technology in the universe. These producers dispose their E-waste by calling auctions. In similar ways, the repair shops have up to 50 % of total E-waste collections, which are being sold to scrap dealers (Parajuly *et al.*, 2017). In Nepal, the general process of recycling is being done by scavengers, scrap hawkers, and scrap dealers, who separate the reusable parts and illegally export to a foreign country for proper recycling purposes, which seemingly

need attention and monitoring by the concerned authority. The actual practices of waste disposal and recycling in Kathmandu are explained in Fig 6.

In rural areas, people simply dump all their waste products in nearby open places without proper knowledge, and sometimes the burning of non-degradable waste is being practiced in the open air, which is very unhealthy for living beings and the environment.

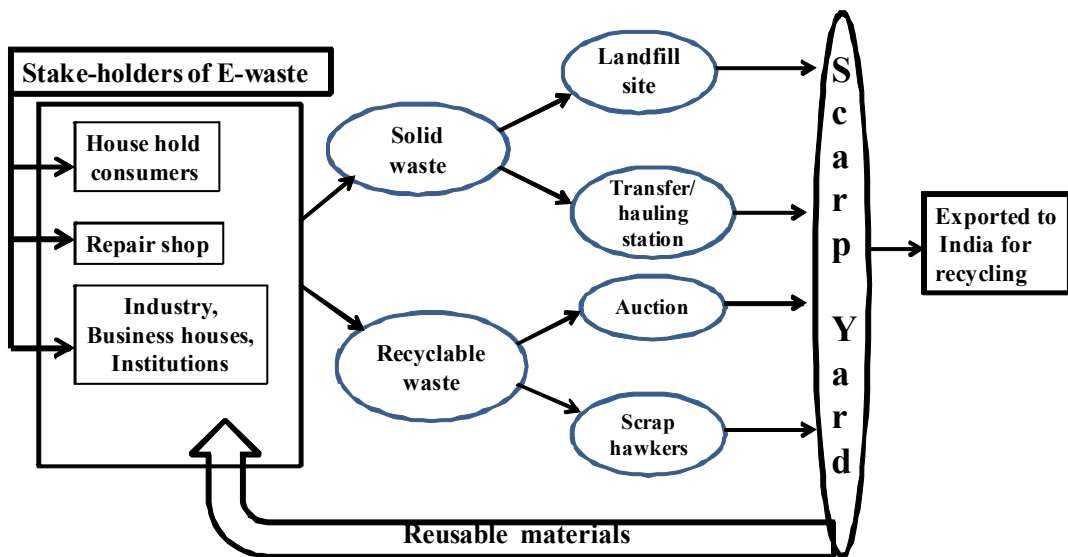


Fig. 6. Schematic chart showing different recycling patterns of solid wastes in Kathmandu valley

Some of the young entrepreneurs have started an initiative to collect solid waste from the community for proper management.

Suggestions and Solutions for Proper Management of E-wastes

The increasing trend of consuming E-gadgets, including personal computers, which ultimately become mixed wastes, is one of the significant challenges. Meanwhile, the sophisticated lifestyle, decreasing market value of E-gadgets and easy access to the market, add more complexities in

(Sawhney *et al.*, 2008; Asian Development Bank 2013).

As E-wastes are being discarded by the society unattended, the real practice for such things should be started from primary consumers by separating it from other wastes and help to dispose of in the correct place (Sawhney *et al.*, 2008; Kalana 2010). Additionally, the manufacturer should take responsibility for the proper disposal of the product after being used (Mansfield 2013). The systematic process should start with the door to

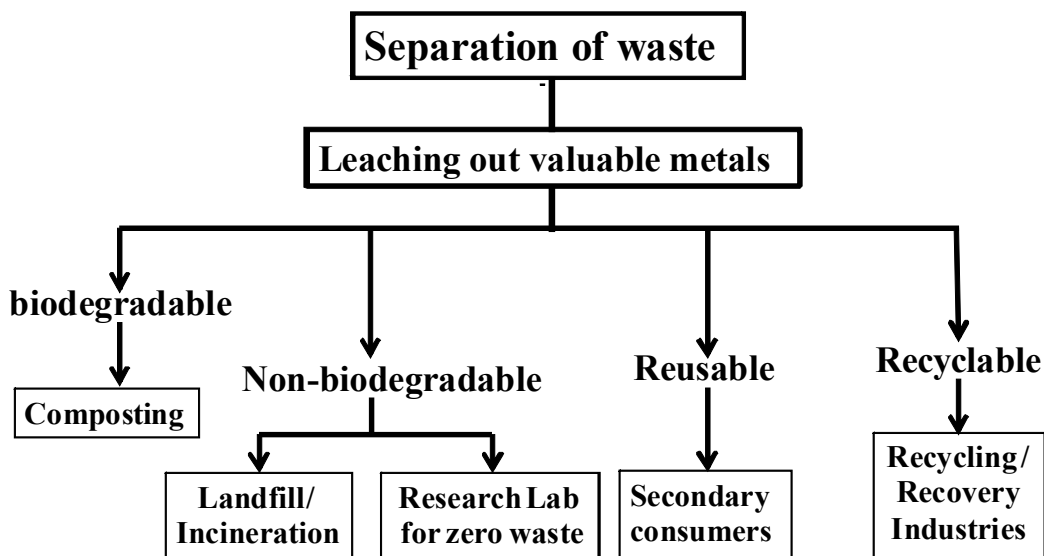


Fig. 7. Schematic outline showing different steps recommended for the proper E-waste management

the E-wastes management issues. (Widmera *et al.*, 2005). The proper E-waste management is only possible if it lies in the national agenda of the country (Szalatkiewicz 2014), which is unfortunately not the case in our country. Nepal has not even been able to enforce the Solid Waste Management Act 2011 strictly. Thus, public awareness has become essential for targeting the reasonable outcome in solid wastes management, including E-wastes (IPE Global Pvt. Ltd. 2012; Asian Development Bank 2013).

Now, as E-wastes are always increasing, with an awakened mind, one should start to turn wastes into resources, which could support the circular economy of the country. The flow chart depicted in Fig 7 proposes the adoption of 3R principles with additional redesign policy for local purposes

door collection of the E-wastes, leaching out the metal parts using safe chemical treatments such as acid leaching or some biological process (Musson 2000, PACE Nepal Pvt. Ltd., 2017).

The separated E-wastes should be categorized in four groups as shown in Fig 7; (i) biodegradable for composting, (ii) non-biodegradable for landfill or incineration that can be sent to the research laboratory and safe processing units for detoxification and further research to bring in other application so that the waste becomes completely zero, (iii) reusable for secondary consumers and (iv) recyclable to the industry which could be polymers and metal particles (Hiroki 1992, IPE Global Pvt. Ltd. 2012). The proposed format can be used to convert the most impertinent wastes into the resources for new applications and to save

the environment for future generations (Brandl 2001).

Conclusions

The increasing E-waste in society pollutes natural environments, which could be quite dangerous for the wellbeing of life on the Earth. Therefore, the time has come to sense the urgency of proper management of E-waste. Thus, it is necessary to act now to ensure the safety of life and the natural environment on the planet. A few strategies are suggested below as guidelines for addressing the disastrous scenario of E-wastes and the urgency of proper management in Nepal.

1. An essential foundation towards this direction is to provide awareness to the manufacturer, consumers as well as to the general public about the responsible utilization of E-wastes and related management problems and possible hazards.
2. Nepal urgently needs regulatory guidelines to cope with the E-wastes problematic. Strict regulatory actions on both import and disposal should be implemented.
3. The knowledge on the production of E-wastes, hazards, and mitigation measures have to be incorporated in the curriculum of schools and universities.
4. The proposed path for the recovery of expensive and hazardous metals is an essential part of the management, which should be instantly followed by the concerned sectors. It may add an advantage to the economy of the country. Research works in this direction should be promoted.
5. Recycling and recovery of the polymer composites used in E-gadgets are also an essential part of the concern, while their safe incineration to produce energy may be useful. The non-degradable, toxic, and hazardous materials left behind can be studied for their useful applications or detoxification.

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