

**T**HE waste from electrical and electronic equipment, or e-waste, is the fastest-growing waste stream globally.

According to an e-waste directive of Europe, the diverse categories include large household appliances, small household appliances, IT and telecommunications equipment, consumer equipment, lighting equipment, electrical and electronic tools, toys, leisure and sports equipment, medical devices, monitoring and control instruments, and automatic dispensers. Smartphones, wearables and driverless vehicles are more recent examples.

The increased number of devices, intentionally designed for shorter life cycles, are resulting in rapid growth of e-waste worldwide. Growing affluence, consumerism, and hasty discarding for newer models are contributing to the exponential growth of e-waste.

Singapore, with 20kg e-waste per capita, is among the leading generators in the region, and comparable to the other high-income countries around the world.

The National Environmental Agency (NEA) estimates about 60,000 tonnes of e-waste is generated in Singapore every year. About 70 million tonnes of e-waste is generated globally per year. China is the largest producer as well as recipient of e-waste.

E-waste is shipped to the low-cost destinations for re-use, dismantling and parts re-use, incineration, and land-fill. E-waste contains toxic substances.

Its informal disposal and low-technology recycling generates toxic pollutants and heavy metals harmful to the ecosystem. Considering the adverse effects on environment and human health, barriers are coming up for e-waste movement across borders.

For example, this year China banned incoming shipments of over 20 types of solid waste.

On the other hand, e-waste contains valuable metals, and simply discarding amounts to wastage of precious resource.

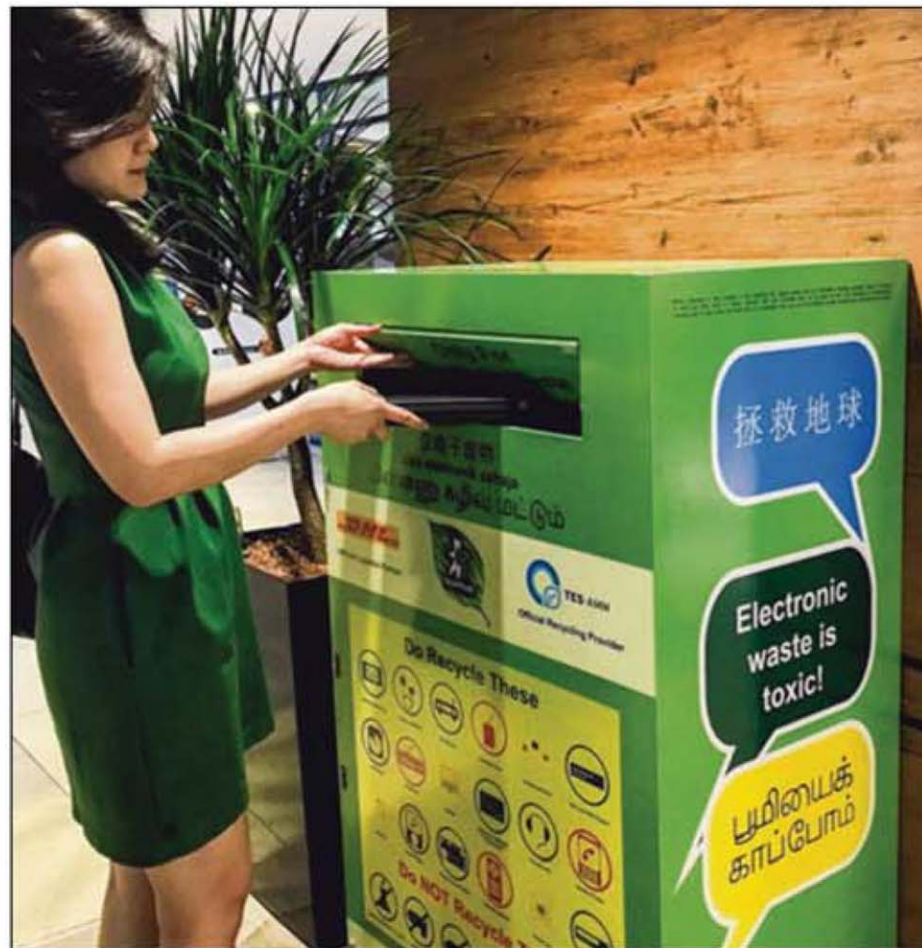
E-products approximately use 100 per cent of the indium, 72 per cent of the ruthenium, 50 per cent of the tin, 44 per cent of the copper, 34 per cent of the silver, and 22 per cent of the mercury mined globally every year.

Recovering raw materials from e-waste is an effective solution to mitigate increasing costs of new raw materials.

Moreover, recycling reduces the amount of greenhouse gas emissions caused by the manufacturing of products from all new raw materials.

Pyro-metallurgical and chemical methods are employed to recover valuable metals. Environmentally benign biotechnology processes using genetically engineered microorganisms are being developed.

# S'pore should aim to be model country for e-waste management



Notable effort... E-waste recycling bin located at Singapore malls to encourage shoppers and tenants to adopt electronic waste recycling.  
PHOTO: CAPITALAND



**innovation**  
SEERAM  
RAMAKRISHNA

Traditional e-waste management involves collection of waste, pre-processing and end-processing for recovery of high value metals.

With global movement towards the circular economy, innovations in terms of more efficient recycling, direct reuse after the

end of life cycle, reuse after repair, and remanufacturing are being pursued.

This requires sophisticated e-waste management systems.

A common feature of e-waste management systems overseas is the Extended Producer Responsibility (EPR) concept, which obliges the manufacturers and importers to be responsible for the collection and environmentally sound disposal of e-waste from consumers.

For example, in Germany, Korea and Taiwan, the costs of e-waste collection and disposal are borne by the manufacturers, importers and retailers.

In Switzerland and Japan, the costs are borne by consumers.

China began EPR in a phased manner. Moreover, European Union set e-waste collection and

recycling targets for member states there by enabling viable e-waste recycling business.

New regulations in Europe and Japan restrict the use of specific hazardous substances in the products there by enhancing the recyclability of e-waste.

A notable recycling effort in Singapore is StarHub's RENEW programme, where more than 400 e-waste bins are placed around the island.

This programme collected approximately 60 tonnes of e-waste in 2016.

While commendable, this is a small fraction of Singapore's total e-waste generated every year. Consumers as well as businesses are unaware of the need to properly dispose of their e-waste for recycling.

Diversity of e-waste is an obstacle for recycling. Emerging digital technologies provide an opportunity to overcome this challenge, and means to evaluate EPR implementation.

For example, wireless GPS location trackers are helpful in monitoring the flow of e-waste.

The massive data generated during the manufacturing, use and disposal fits the characteristics of Big Data.

RFID, QR, block chain, wireless sensor networks, internet of things

(IoT), cloud computing, Big Data business analytics, and Artificial Intelligence (AI) enable new ways to monitor, regulate and enforce rules on the movement of e-waste.

Privacy is another reason for current lower recycling rates, and requires further innovations in digital technologies.

Authors collaborate on data collection for diverse waste characteristics and web-based materials flow analysis to match with recycling solutions.

There are abundant opportunities for innovations to enhance the recovery of valuables from the e-waste, and to eco-design products.

The environmentally sound management of e-waste is a complex activity. This requires behavioural change as well as innovations on multiple fronts.

Effective e-waste management provides opportunities for creating new jobs. It enables Singapore to transition into a smart and liveable city, efficient, and green economy.

As the sustainable management of e-waste is a growing concern of all countries, Singapore can strive to provide an example to emulate.

▀ [tabla@sph.com.sg](mailto:tabla@sph.com.sg)

*Professor Seeram Ramakrishna,  
Chair of Circular Economy  
Taskforce, National University of  
Singapore*