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# A REVIEW ON MOBILE ELECTRONIC WASTE RECYCLING AMONG MALAYSIAN USERS

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***ABSTRACT***

*The increase of electronic gadgets and appliances has led to a higher amount of mobile electronic waste (e-waste). Despite that, the awareness among Malaysian users regarding mobile e-waste recycling remains deficient. Our reviews clearly show that users' awareness on mobile e-waste recycling is to assess their understanding and knowledge level based on the Knowledge, Attitudes and Practices (KAP) model proposed by Schwartz (1976). Further, mobile e-waste recycling intention and motivation is closely linked to an individual's environmental mindset, incentive strategies, environmental education, convenience and disposal cost. Additionally, Malaysian Communications and Multimedia Commission (MCMC) and Non-Government Organizations (NGOs) have introduced various methods, platforms and practices on mobile e-waste recycling. There is no clear review of mobile e-waste recycling among Malaysian users, driving this study conducts a review of Malaysian users' awareness and perception, intention, motivations, methods and platforms on mobile e-waste recycling. This study helps the policy makers to enhance information dissemination of mobile e-waste and support Sustainable Development Goals (SDGs) namely clean water and sanitation (goal 6), sustainable cities and communities (goal 11), responsible production and consumption (goal 12). This study helps to detect the limitations of the Malaysian users on advancing awareness for more sustainable mobile e-waste recycling.*

***Keywords:*** Mobile electronic waste recycling, Knowledge, Attitudes and Practices (KAP) model, Awareness, Motivations, Mobile e-waste recycling methods, Sustainable Development Goals (SDGs).

## 1. INTRODUCTION

The increase of electronic gadgets and appliances has led to a higher amount of mobile electronic waste (e-waste) (Chang, Yue, Qureshi, Rasheed, Wu & Peng, 2023; Kazancoglu, Ozbiltekin, Ozen & Sagnak, 2021). In 2010, only 14% mobile phone users used smartphones in comparison to 94.8% in 2021 (Handphone users survey, 2021). Generally, smartphones and other mobile devices tend to have a lifespan of two to three years before they are replaced due to physical damage, security and software update limitations, outdated hardware and short battery longevity (Handphone users survey, 2021). For instance, the absence of software updates result in malfunctioning versions of an application, the absence of certain features, all of which can contribute to smartphones optimizing their batteries faster than anticipated. After users stop their smartphones and mobile devices, they tend to keep their old devices or dispose of them as part of household garbage (Yeoh, 2023). Hence, it is not surprising to find that in 2016, the average of mobile e-waste was 6.1 kg per capita, an increase from 5.8 kg per capita recorded in 2014 (Afroz, Muhibbullah, Farhana & Morshed, 2020). Quantity of mobile e-waste is expected to rise to 6.8kg per capita by the year 2030 (Afroz et al., 2020). The largest amount of mobile e-waste totalling 18.2 million tons was produced in Asia followed by Europe (12.3 million tons), America (11.3 million tons), Africa (2.2 million tons) and Oceania (0.7 million tons) (Afroz et al., 2020).

In Malaysia, e-waste is a scheduled waste with the code SW110 under the First Schedule of the Environmental Quality Regulations (Scheduled Waste) 2005, referring to the Environmental Quality Act 1974 under Department of Environment (Ismail & Hanafiah, 2021). Code SW110 refers to waste generated from electrical and electronic equipment that contains components like accumulators, mercury switches, cathode ray tube glass, activated glass and other similar materials (Department of Environment, 2022). E-waste is classified as scheduled waste due to its properties of ignitability, corrosiveness, reactivity and toxicity (Devados, Agamuthu, Mehran, Santha & Fauziah, 2021). E-waste generation is categorized into two sources: the industrial and household (Ahmad, Akram, Husain, Ahmad, Sharma, Prakash & Ahmed, 2023).

Since 2012, mobile e-waste disposal has become a significant issue in Malaysia (Yahya, Hamzah & Shafie, 2022). Materials in smartphones such as lead, cadmium and mercury pose health and environmental risk (Nadarajan, Vafaei-Zadeh & Hanifah, 2023). Those who burn mobile e-waste have exhibited increased lead concentration in their blood (Orisakwe, Frazzoli, Illo & Oritsemuelebi, 2019). Human exposure to toxic chemicals can result in respiratory, heart disease, disruptions in hormone levels, weakened immune system, urine system disorder, old age dementia and difficulties in learning (Orisakwe et al., 2019). Therefore, it is crucial to ensure mobile e-waste is disposed of when they are no longer in use (Thakur & Kumar, 2022). In Malaysia, mobile e-waste disposal must adhere to regulations in the Environmental Quality Act 1974 of DOE (Mahat, Hashim, Nayan, Salleh & Norkhaidi, 2019). Mobile e-waste belongs to the schedule waste category, specifically under SW110 (Mahat et al., 2019). Essentially, mobile e-waste cannot be disposed of in the same manner as regular solid waste.

In November 2022, the Malaysian Communications and Multimedia Commission (MCMC) has introduced an initiative “i.e., KITAR (previously known as "Mobile e-Waste: Old Phone, New Life") to contribute mobile e-waste recycling and aligns with Department of Environment (DOE) efforts in mobile e-waste management (KITAR, 2023). Despite that, the awareness among Malaysian users regarding mobile e-waste recycling remains deficient (Yeoh, 2023). The majority of users retain their old smartphones and dispose of them with household waste (Yeoh, 2023). Only a small number of users had utilized mobile e-waste prepared by MCMC at community internet users or Malaysian Family Digital Economy Centers to discard their mobile e-waste (Yeoh, 2023).

Despite that, few questions cannot be answered because past studies (Afroz et al., 2020; Mahat et al., 2019) do not understand mobile e-waste recycling in particular. For example, to what level Malaysian urban and rural users’ awareness and perception on mobile e-waste recycling? What are their intentions and motivations on mobile e-waste recycling? And what are their methods, platforms on mobile e-waste recycling? Hence, this paper offers an overview of Malaysian users’ awareness and perception, intention and motivations, methods and platforms on mobile e-waste recycling. As such, this study is an essential tool for the policy makers to enhance information dissemination. This study helps to detect the limitations of the Malaysian users on advancing awareness for more sustainable mobile e-waste recycling.

## 2. RESULTS AND DISCUSSIONS

### Conceptualization of mobile e-waste recycling

Mobile e-waste is malfunctioning or outdated small electrical and electronic items such as laptops, feature phones, smartphones, cameras, power banks, tablets, phablets along with its chargers and accessories (Department of Environment, 2022). Mobile e-waste recycling is the

process of breaking down mobile e-waste into small pieces that can be reproduced as a new electronic device (Wu, 2023).

**Impact of mobile e-waste on health issues**

Mobile e-wastes are made of dangerous, imperishable components such as lead and mercury that could potentially harm health and environment (Department of Environment, 2022). If e-waste is disposed of in lands or rivers which release toxic chemicals, affecting the environment and health (Noor, Soleman & Azuan, 2023). For example, chromium compounds damage the body's DNA, leading asthma and other illness (Noor et al., 2023). E-waste also has gold, copper, palladium, and silver, which bringing large recycling benefit (Department of Environment, 2022).

**Mobile e-waste recycling awareness and perception**

Evaluating users' awareness and perception of mobile e-waste recycling is important for checking their understanding and knowledge level (Yahya et al., 2022). In this study, users' awareness and perception of mobile e-waste recycling is divided into three components: knowledge, attitudes and practices referring to the early Knowledge, Attitudes and Practices (KAP) model proposed by Schwartz (1976) (refer to Figure 1). It describes the existence of awareness and perception through three components: knowledge, attitudes and practices (Munoz-Mazon, Villace-Molinero, Fuentes-Moraleda & Jimenez, 2024; Schwartz, 1976). KAP model have become a commonly employed approach for investigating human behavior in numerous areas. Indeed, the KAP model has been widely found in environmental issues such as mobile e-waste recycling (Decharat & Kiddee, 2022). Each component is examined within the context of three sustainability domains: environmental, social and economic (Barbier, 1987, Liao, Nguyen & Sasaki, 2022) (refer to Figure 2). This involves assessing citizens' awareness, perceptions and behaviors related to recycling behaviors (Nordin & Saliluddin, 2016), landslides (Lateh & Ahmad, 2011), solid waste open burning (Ariffin & Wan Yacoob, 2017), solid waste practices (Barloa, Lapie & De La Cruz, 2016), uncontaminated water standard (Razak, Praveena, Aris & Hashim, 2016) and mobile e-waste (Mahat et al., 2019).

Hence, understanding three components: knowledge, attitudes and practices related to mobile e-waste recycling is crucial as stated by Eidham, Aswad and Adilla (2022). Several foreign nations including Thailand, Africa have undertaken similar research, revealing low awareness levels regarding e-waste recycling. For example, a study by Owojori, Mulaudzi and Edokpayi (2022) reported the understanding and perception of solid waste disposal is inadequate among the students of rural-based educational institutions. It can be seen that 88% of the students did not familiar those people in charge for solid waste disposal (Owojori et al., 2022). Another example is a study by Okoye and Odoh (2014) demonstrated lack of public awareness in Anambra, Onitsha, Africa about government regulations on e-waste disposal and e-waste health impacts. There is no exception on Malaysians' low awareness levels regarding mobile e-waste recycling. Afroz, Masud, Akhtar and Duasa (2012); Akhtar, Masud and Afroz (2014) reported that respondents acknowledged electrical and electronic devices cause environmental

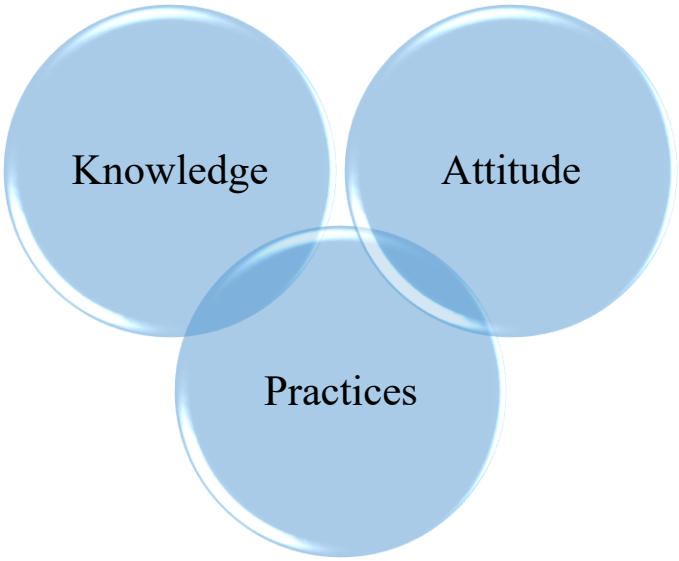


Figure 1. Knowledge, attitudes, practices (KAP) model

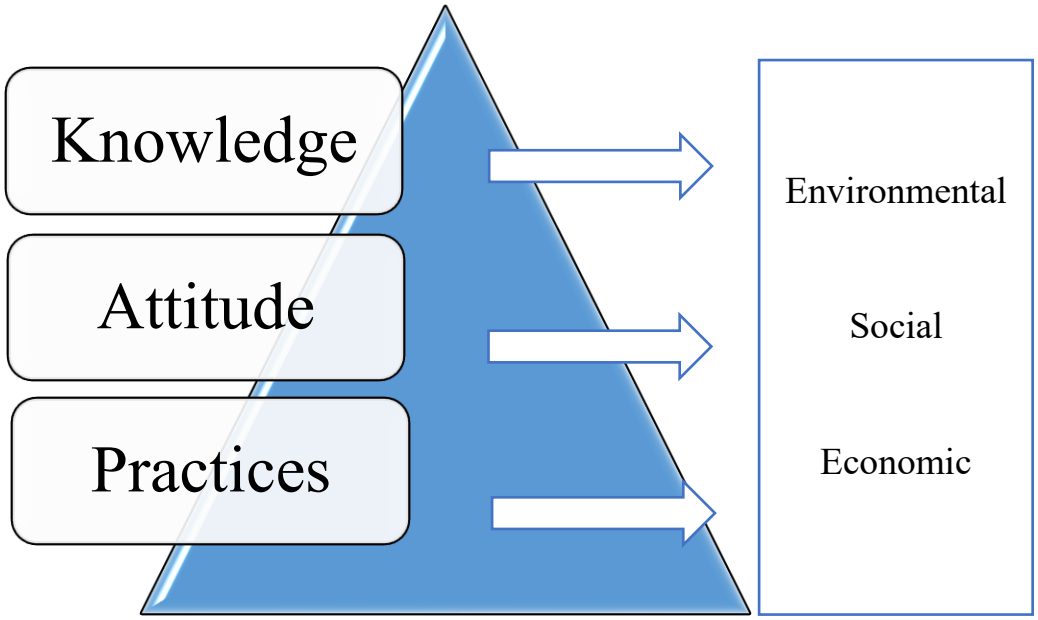


Figure 2. KAP model in three sustainability domains.

issues, however they have no clear understanding on how to recycle mobile e-waste. In the similar vein, Kalana (2010) study focused on public awareness and knowledge in Shah Alam revealed that the respondents possessed a strong understanding on mobile e-waste except for proper methods of mobile e-waste recycling.

**Mobile e-waste recycling intention and motivation**

Mobile e–waste recycling is closely linked to an individual's environmental mindset and these mindsets have substantial impact on their actions (Otto, Evans, Moon & Kaiser, 2019). Hence, assessing environmental mindset is crucial in shaping and encouraging people's actions concerning the natural environment (Otto et al., 2019). Those who hold an environmental mindset tend to manifest in their daily behavior, activities and practices (Izhar, Yusof, Akira & Kamari, 2022). As reported by Yeow and Low (2018), individuals who consistently recycle their old computers tend to have a higher likelihood of recycling other forms of waste.

Individual's environmental mindset are shaped by psychological factors, including personal values as well as the influence of close friends, family and social groups (Rosa & Collado, 2019). For instance, if individuals are concerned about environmental problems caused by pollution and massive deforestation that could impact their friends, family and it will lead to feelings of anxiety and insecurity.

Incentive strategies hold the potential to boost the mobile e–waste recycling as financial rewards can motivate businesses and individuals to align their financial goals with environmental objectives (Zhong, Zhou, Zhao, Zhang, Nie & Simay, 2022). For instance, Brazil has a program where residents receive credits on their electrical bills for participating in recycling behavior (Zhong et al., 2022). In Surabaya, Indonesia, people can use bottles as forms of payment for public transportation fares (Oh & Hettiarachchi, 2020). Kuala Lumpur has a Recycling Reverse vending machine, an automated device that rewards users with RM 0.05 for each recycled item (National Security Council of Malaysia, 2022). Recycling centers are located in urban and metropolitan areas (National Security Council of Malaysia, 2022). For example, in the Klang Valley region, both municipal authorities and private organizations offer several recycling facilities such as UrbanR Recycle+, SOLS Tech and Senheng E-Waste Recycling Program (National Security Council of Malaysia, 2022).

Providing education is the fundamental strategy to enhance awareness, knowledge and engagement in environmental problems i.e., mobile e-waste recycling. This viewpoint is reinforced by a study conducted by Islam, Dias and Huda (2021) which claimed environmental education enables young children to shape values and involvement in mobile e-waste recycling. Wakhidah and Erman (2022) has found that Indonesia junior and senior high schools have incorporated environmental education content such as humans as social beings, natural resources into Islamic religious curriculum. This is to develop a more thorough treatment of environmental issues and deliver relevant attitudes to care for the natural environment (Wakhidah & Erman, 2022). Informal education can begin within households as recommended by Otto et al. (2021). Empirical studies (Adeel, Nayab, Qureshi & Channa, 2023; Swanson & Ferrari, 2022) have indicated that strong understanding of environmental friendly practices correlates with the increase adoption of practices such as conserving electricity, saving water, practice 3Rs (reduce, reuse, recycle). Therefore, it is evident that imparting knowledge through education is the primary means of promoting awareness and engagement in the context of mobile e-waste recycling.

Ease and convenience play a crucial role to stimulate mobile e–waste recycling behavior (Gonul Kochan, Pourreza, Tran & Prybutok, 2016). People are more inclined to opt for landfills when recycling options available are accessible via local authorities (Sidique, Lupi & Joshi, 2010). By expanding the number of locations for collecting recyclable items, households are more likely to be motivated to take part in recycling initiatives. Vijayan, Krishnan, Parayitam, Duraisami and Saravanaselvan (2023) demonstrated that the main factor that influences an individual's likelihood of recycling is the level of ease associated with the recycling process. People who perceive that they have a higher degree of control over their actions are more inclined to recycle (Vijayan et al., 2023). Recycling may be viewed as a burden when it needs more effort and is complicated (Kumar, 2019).

Diekmann and Preisendorfer (2003) discussed the concept of disposal cost, which can be categorized as low or high. These two categories have distinct impacts on behavior, with lower cost influence behavior to a large extent in comparison to higher cost. The perceived cost of disposal is influenced by factors such as time available, length, scope and the ease of performance operations associated with the items being disposed of.

**Methods, platforms and practices on mobile e-waste recycling**

After the mobile phone reaches the end of its life cycle, an e-waste recycler will collect the device using secure containers to ensure the privacy of all data (Greentec, 2023). Once the devices are collected, detailed documentation is initiated which plays a crucial role in monitoring the devices and any sensitive information during the entire transportation and recycling process (Greentec, 2023). Upon reaching the processing facility, the devices are unloaded. Subsequently, the recycler utilizes their inventory management system to identify, categorize, label, scan and record all items (Greentec, 2023). This process guarantees security and sustainability.

If mobile phones are found to be in good condition and suitable for reuse, they may be sent for refurbishment. During this process, data is securely wiped and the devices are audited for make, model and serial numbers to enable secure asset tracking (Greentec, 2023). However, if the devices are used for recycling, industrial-grade shredders can break them down and ensure data within mobile phones are protected (Greentec, 2023). At this stage, materials are physically separated into basic commodities for recycling plastic, glass, steel, aluminium, copper and precious metals (Greentec, 2023). Hazardous materials like lithium-ion batteries are diverted into the recycling process to prevent environmental impact while valuable materials are reintroduced into the circular economy for the manufacturing of new products, such as new mobile phones (Greentec, 2023).

Under the KITAR program, the public has the option to deposit or discard their old electronic devices and gadgets into collection boxes of KITAR at specified drop-off locations (KITAR, 2023). Subsequently, recycling companies will gather and transport to Full Recovering Facility (FRF) to guarantee their appropriate disposal and the recovery material for reused purpose (KITAR, 2023). The recovery material will be employed in the production of new goods (KITAR, 2023).

Non-Governmental Organizations (NGOs) have active involvement in household mobile e-waste recycling initiatives with MCMC and DOE (Yong, Lim, Ilankoon, 2019). For instance, Tzu Chi has independently financed over 512 recycling locations and facilities throughout Malaysia (Taiwan Buddhist Tzu Chi Foundation Malaysia, 2015). Tzu Chi collects computers, car batteries and consumer appliances (Taiwan Buddhist Tzu Chi Foundation Malaysia, 2015). This suggests utilizing NGOs in mobile e-waste could enhance and reinforce the current household collection system (Yong et al. 2019).

## 3. CONCLUSIONS AND SUGGESTIONS

In the age of globalization, the utilization of electrical and electronic gadgets like smartphones, computers and household appliances, is on the rise, in tandem with technological advancement. Such a situation causes an increase in mobile e-waste. Improper mobile e-waste disposal results in the release of metals into the land. Mobile e-waste presents a danger not only to the environment but also individual well-being. Mobile e-waste management Malaysia was established in 2015 under the authority of the DOE. Despite that, users reported lower levels of awareness on mobile e-waste recycling.

Reviewing literature showed that evaluating users' awareness on mobile e-waste recycling is to check their understanding and knowledge level. In this study, users' awareness on mobile e-waste recycling is divided into three components: knowledge, attitudes and practices referring to the KAP model. Further, mobile e-waste recycling intention and motivation is closely linked

to an individual's environmental mindset, incentive strategies, environmental education, convenience and disposal cost.

The study will be used as input to strengthen more promotional campaigns and marketing initiatives on e-waste in the future. This is needed to increase public awareness. By doing this, the public understands why they must handle e-waste in a responsible manner, how they can competent in solving e-waste problem and where they can find the drop-off points. Hence, it improves the 3R's (Reduce, Reuse, Recycle) culture in Malaysia.

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