SOUTHAMPTON SOLENT UNIVERSITY

SCHOOL OF MEDIA ARTS AND TECHNOLOGY

MSc Cyber Security Engineering

Academic Year 2021 - 2022

Stefania Alina Nuca

E-waste and the impact that recycling E-waste has on human health and environment.

Supervisor: Andy Farnell

Module Leader: Dr Femi Isiaq

Table of contents

Acknowledgements

Firstly, I would like to thank Andy Farnell for his patience and for the support provided.

Next, I would like to thank my family for the emotional support.

Chapter 1

What is E-waste?

E-waste is the disposal of any electronic device that a consumer (person/organization) intends to replace. Electronic waste is one of the most hazardous types of waste in the world. People are not aware of the harmful effects that this type of waste have on environment and human's health. There are devices that people use and they contain PFAS (long lasting chemicals / forever chemicals). These devices end up in poor countries, in recycling centres, where millions of children and women work without personal protection equipment to collect the precious metals from these devices. According to World Health Organization, the pandemic has also created a ''tsunami of E-waste''. Many people started working from home and bought new devices while throwing away old but still functioning devices. The E-waste goes to poor countries where they are recycled. The recycling centres in these countries do not provide adequate PPE. Moreover, in this type of centres most ''employees'' are children and women. Children are preferred for this job as they have small hands and they can easily disassemble the devices. There are 12.9 million women and more than 18 million children working in this informal industrial sector. It is shocking that some children are as young as 5 years old and they are working with chemicals without using adequate PPE. There is also an issue with the position of E-waste recycling centres near schools or homes and children even play around these centres. The impact is huge on health. (World Health Organization, 2021)

Precious metals found in devices are Gold, Silver, Palladium, Platinum, Iridium, Nikel, Osmium, Rhodium, Ruthenium, Copper and others. Every precious metal is used for a different thing and every single piece of a device needs to be disassembled. For instance, gold is used in connectors, switch and relay contacts, wiring, thin-film layers, protective coatings and other. Silver can be found in high-voltage contacts, laptop batteries and button batteries. (Prince and Izant, 2015)

But how much gold can be found in a computer and is its value? According to Christopher Mccfaden, a tone of E-waste contains 40-800 more times gold than an actual gold ore. (Mcfadden, 2020)

A computer contains around 0.2grams of gold and it is valued at $12. A mobile phone also contai ns around 0.034 grams of gold and it can be valued to $1.83. (Something borrowed, 2022)

For every one million of mobile phones recycled, the following amounts of precious metals are being collected: 35,274 pounds of copper, 772 pounds of silver, 75 pounds of gold, 33 pounds of palladium. (Lubell, 2018)

The impact that E-waste can have on human health was presented by World Health Organization.

While a pregnant woman is working in a recycling centre, she is aiming to get the precious metals from devices. At the same time,she is exposed to toxic metals. This can seriously affect her and her child. For instance, exposure to toxic metals can create damages to DNA, the child can have behavioural problems, ADHD, sensory integration difficulties and reduced cognitive and language scores. There are also risks of changes in lung function, respiratory effects, risk of chronic diseases, cardiovascular diseases or cancer. (World Health Organisation, 2021)

Not only human health is affected but the environment is also affected. An example provided by the World Health Organization is a child that eat a chicken egg from Ghana, will absorb 220 times the European Food Safety Authority daily limit of chlorinated dioxins. A toxic environment leads to children being born with smaller size bodies orless developed organs.(World Health Organization, 2021)

We usually generate around 40 million tons of E-waste every year, worldwide. But in 2019, the planet has reached a record of 53.6 million of tones of E-waste. Half of this amount of waste was produced in China. China was accounted for the amount of e waste produced in 2019 as they have reduced prices and made electronics more affordable. Statistics show that Europe has the highest amount of E-waste per capita with 16.2 kg, while America has 13.3 kg and Asia 5.6 kg of waste per capita. (Tiseo, 2021)

In 2021, 57.4 milion metric tones of E-waste was generated. From this huge amount of waste only 17% is being properly recycled. While China, US and Indiaproduce the most E-waste by volume, there are also countries like Estonia, Norway and Iceland that have the highest rate of e-waste recycling. In the last few years, the amount of E-waste has significantly increased and statistics show that in 2030 the amount of E-waste that will be generated will be around 74.7 millions metric tons. (Ruiz, 2022)

Moreover, counties that produce the most electronic waste have the smallest percentage of recycling. For instance, China produces 10129 Kilotones of e waste from which only 16% is being recycled. USA produces 6918 kilotones of e-waste and recycles 15%. India produces 3230 kilotones of electronic waste and recycles 1%. European countries have a higher rate of recycling. For example, UK produces 1598 kilotones and recycles 57%. Germany also have a percentage of 52% and France has a rate of recycling of 56%. (Ruiz, 2022)

What is the cause of increasing E-waste?

Planned obsolescence is a concept that many people are not aware of. It is also called the

''expiration date effect''. This is a strategy where businesses plan the obsolescence of a product from the beginning. The obsolescence of a product is built into the product from its conception, by the manufacturer. This strategy is being used to make customers to buy the new products which are supposed to be better than the old ones. The truth is that companies only produce the same items every year, with minor changes to keep their customer base. (Kramer, 2012)

There are four types of planned obsolescence: contrived durability, software updates, perceived obsolescenceand prevention of repair. For instance, an example of prevention to repair is someone who owns an apple smart phone and wants to replace the battery. It is very hard to replace the battery or any other component as for this it is needed to have special tools. Perceived obsolescence is a common form of planned obsolescence and an example of perceived obsolescence is that companies that produce smartphones keep producing a new product every year. They are also being advertised as bigger screens, long lasting batteries,more powerful. They are supposed to be better that their old versions. Moreover, an example of planned obsolescence using software updatesis when a printer does not work anymore. Updating drivers doesn't work. It is found out that the printer is no longer compatible with the updated operating system. This way, a software update can be used for planned obsolescence. Contrived durability is when parts of an item break down intentionally and the customer will need to buy a new product. Another examples of planned obsolescence are slowed down iPhones. (Soke, 2021)

E-waste recycling challenges

A major challenge of electronic waste recycling is the lack of recycling policies. Many people are confused and do not know how to recycle electronic waste. Another challenge is represented by the hazardous components that electronic waste contain. Handling toxic metalsit is dangerous and specialized equipment is required. Moreover, the short life-cycles of new devices also represents a challenge of E-waste recycling. Moreover, the recycling process of electronic waste is complicated. For instance to build a computer, 1.5 tons of water is used, 48 pounds of chemicals, 530 pounds of fossil fuel. In order to recycle the 48 pounds of chemicals businesses that produced them need to be equipped to handle them. Moreover, the cost ofrecycling is biggerthan the cost of producing the device. Another challenge to E-waste recycling is that many electronics are not being designed to be recycled. (TechReset, 2022)

There is also a major problem in illegally exporting E-waste. Millions of tones are being exported to poor countries under false pretences. They are being classified as ''used goods'' (they are supposed

to be functionable), while they are non-functionable. These illegal actions are being committed in order to avoid costs for legitimate recycling. There are millions of tones of E-waste and it is hard to keep a track. Africa and Asia are the main destinations where E-waste goes. (Interpol, 2013)

UK was also included in a huge scandal of illicit trade of electronics. The Environmental Investigation Agency revealed a system failure of E-waste export in UK. During an 18 months undercover operation, it was discovered that UK is exporting electronic waste which is stripped down to bare components and shipped to countries like Ghana and Nigeria. A number of firms were involved in this illicit trade and UK was discovered to be a large contributor to the problem. The electronic waste was labelled as ''personal effects" or ''used household goods''. (EIA, 2011)

The WEEE (Waste Electric and Electronic Equipment), regulation came into law in 2003. It was updated in 2019 to cover more categories. Under this law, businesses are responsible for the equipment they manufacture. The businesses are also responsible under the same law for the waste that their equipment produces during its lifecycle. (Cotterell, 2020)

The current E-waste legislation is mostly focused on restrictions on import/export. It also includes regulations for recycling specific categories of E-waste and Extended Producer Responsibility. The legislation is also created to address the country-specific problems. There are countries that need specific legislation for export of E-waste and countries which need specific legislation for import of Ewaste. The biggest issue is that legislation is not improved and it does not cover many things. There is a lack of laws regarding E-waste. (Patil, 2020)

Statistics show that in 2014 61 countries had implemented E-waste legislation. The number has slowly increased and the number of countries covered by E-waste legislation in 2019 is 78. It is an improvement but less than half of them really follows the rules and have initiatives of a proper Ewaste recycling. (Tiseo, 2020)

Conclusion

E-waste is a huge problem at the moment. There is a lack of legislations to cover all aspects of importing, exporting and recycling and the impact that recycling has on human health and environment at the momentis huge. The amount of E-waste world wide is also huge and it is hard to keep a track. the solution to this problem is a web application called ''Don't throw me away''. This application will encourage people to keep their devices for a longer period of time. This application will show the worth of a specific device. For instance, someone using a phone will be able to see the amount of precious and toxic metals that the phone contains and the value of each component.

Chapter 2

How to reduce Electronic Waste?

The climate is changing. Global warming affects our health and lives as it is reaching high levels. The changes happen at a high speed. The ability of growing healthy food, breathing fresh air or living life without being affected by the climate changing are decreasing. The ''climate refugees'' number of people is also expecting to rise. This is a huge challenge, but the problems have been identified and solution were proposed. (United Nations, 2022)

Humans generate all types of waste. One type of waste is electronic waste, also known as E-waste. This type of waste is increasing. As technology is developing, people have created a culture named throw away culture. Nowadays most people buy constantly the latest must-have gadgets without realising that the old gadgets they have are fully functional or could be reused. They end up using the new gadgets and throwing away gadgets that can still be used. Scientists encourage people to reuse old gadgets or to recycle them. (Bourne, 2022)

Recycling E-waste is also a huge problem. It is suggested that only 20% of the E-waste is recycled. There are many recycling centres that do not follow rules and electronic waste is not recycled properly. The chemicals have a huge impact on the environment. For instance, most electronic contain mercury, cadmium, beryllium, etc. Those are hazardous chemicals. When electronic waste are left on a landfill, the chemicals end up in the soil, waterways and air. The soil, water and air become toxic and have a negative impact on animals and humans. (Miller, 2022)

Methodology and method

Qualitative and quantitative research is used in this pilot project. Primary sources were used when conducting qualitative research and secondary resources were used to conduct quantitative research.

Aim

The aim of the report is to reduce throwing-away culture. Electronic waste is destroying the environment and killing the planet. Digital can improve our lives and save the planet if used wisely. In order to reduce throwing away culture, it is very important to understand why people throw away their gadgets so easily. There is much software and hardware but there is low quality and they do not last long. Planned obsolescence is a strategy that many companies use. This negative strategy it is used to make low quality gadgets, while they will create new models every year with new design and described as better quality and make people buy their gadgets again. Moreover, many phones

or gadgets are designed with custom screws to make it hard or impossible to fix. Strategies are made for profit, but they have a negative impact on the environment. 90% of resources used to make electronics ends up as waste in a short period of time. The impact from extraction and production of metals has increased twice since 2000. This is also called extreme waste. There are gadgets that are accurate when used for predictions or to analyse data on climate. Digital have a massive potential if used in positive ways. (McGovern, 2020)

Results

In 2020, the European Parliament voted for universal charging method for mobile phones. It was estimated that more than 51,000 tones of obsolete cables were thrown away per year. The European Parliament came up with this solution in order to reduce the amount of waste created every year. Digital companies were not very happy about this. For instance, Apple made an official statementin response to that. They argue that these regulations will freeze innovation while they

4

are supposed to encourage it. Moreover, Apple also stated that the proposal is bad for the environment and disruptive for their customers. (McGovern, 2020).

The Global E-waste monitor quantified that 5.1 Mt of electronic waste crossed country borders. Only 1.8Mt is shipped in a controlled manner while the rest (3.3Mt) is shipped in an uncontrolled manner. Moreover, the quantity shipped in an uncontrolled manner may favour some illegal movements as well. (UNITAR, 2022)

The amount of e-waste is increasing. It is estimated the amount of e-waste will increase to 70 million tones in 2030 if no action is taken. An estimated 50 tones of mercury it is lost every year. Most of the time the electronic waste ends up in landfills. The effects of toxic metals on the landfills have a huge impact on human's health by destroying the environment. Studies show that baby can be affected when the mother lives in a toxic environment. Her body will be affected and when she is breastfeeding. This can cause serios health problems such as memory or cardiovascular issues. Moreover, the organs can also be affected. (Graham, 2020)

Regions that produce the most e-waste on the planet are Asia, America and Europe. In comparison to this, Europe is the region that recycles the most, with a percentage of 42%. America recycles only 9.4% and Asia 11.4% of their e-waste. (Ruiz, 2022)

Asia 24.9 metric tones

America 13.1 metric tones

Europe 12 metric tones

The amount of recycled electronic waste should be increased and improved. But there are still countries that have little to no regulations regarding e-waste. In 2014, some countries started to implement regulations and they have been improved, since. For instance, in 2017 Northern Europe had the highest rate percentage of population covered by electronic waste regulations, with 100%. In comparison, there are countries in Northern Africa that had no regulation at all regarding electronic waste. (Global E-waste Monitor, 2017)

5

Analysis

When a digital item is made there are many costs to be covered. For instance, to produce a computer it is needed 1.5 tons of water, 48 pounds of chemicals and 530 pounds of fossil fuels. The computer will be used for short period of time than replaced with another computer. In addition to the resources used to manufacture the computer, will be added resources spent to recycle the computer. The amount of resources used in total is huge. (Leblanc, 2020)

For instance a smart phone contains the following metals and their value is:

Gold 0.034g £0.56

Silver 0.34g £0.07

Palladium 0.015g £0.34

Aluminium 25g £4.99

Copper 15g £0.09

£6,05 (Total)

Electronics can be sold to companies like CeX. For instance the price for an Iphone 5 is £24. In 2012, when Iphone 5 was released, the price was £529.

6

The aim of the report is to encourage recycling and reusing. In this case, is not a great deal to sell a n Iphone 5 for £24. The other option is reusing. There are many ways to reuse an old phone. For instance, an old phone can be used as a back up device, baby monitoring camera, video door-bell (the phone will be used as a full time monitor), Google Home (instead of spending money on Alexa), alarm clock, etc. There are many more options such as turning the phone into a remote control or installing Linux on it. Moreover, a later version of operating system can be installed on old phones and used instead of paying for a new phone. (Broida R., 2017)

Conclusion

In conclusion, the results and analysis show the huge amount of E-waste that has a negative impact on the environment and human's health. In order to stop the throw-away culture and to encourage people to recycle and reuse when possible, an old Iphone (Iphone 5) is used in different useful ways. Moreover, a web app will be created using a database, which shows the value of the components of a device (Phone/laptop/PC) and the costs of getting rid of the toxic components. A full scale study is needed for a better understanding of the impact that E-waste has on our planet and to present a solution.

Chapter 3

Introduction

The environment is affected in many ways. Electronic waste is a huge problem nowadays. There are many factors that can be mentioned in order to improve electronic waste management such as awareness and culture. People need to be aware that by disposing electronics to collection points it is very important. By recycling electronics, many resources can be re-used and the environment is also protected. When electronics are not recycled, they end up with mixed waste and then incinerated or landfilled and the resources are lost and the environment will be affected. For instance, the resources that can be collected and re-introduced into manufacturing cycle at every million cell phones are:

-16 000 kg of copper

-350 kg of silver

-24 kg of gold

-14 kg of palladium (WEEE, 2019)

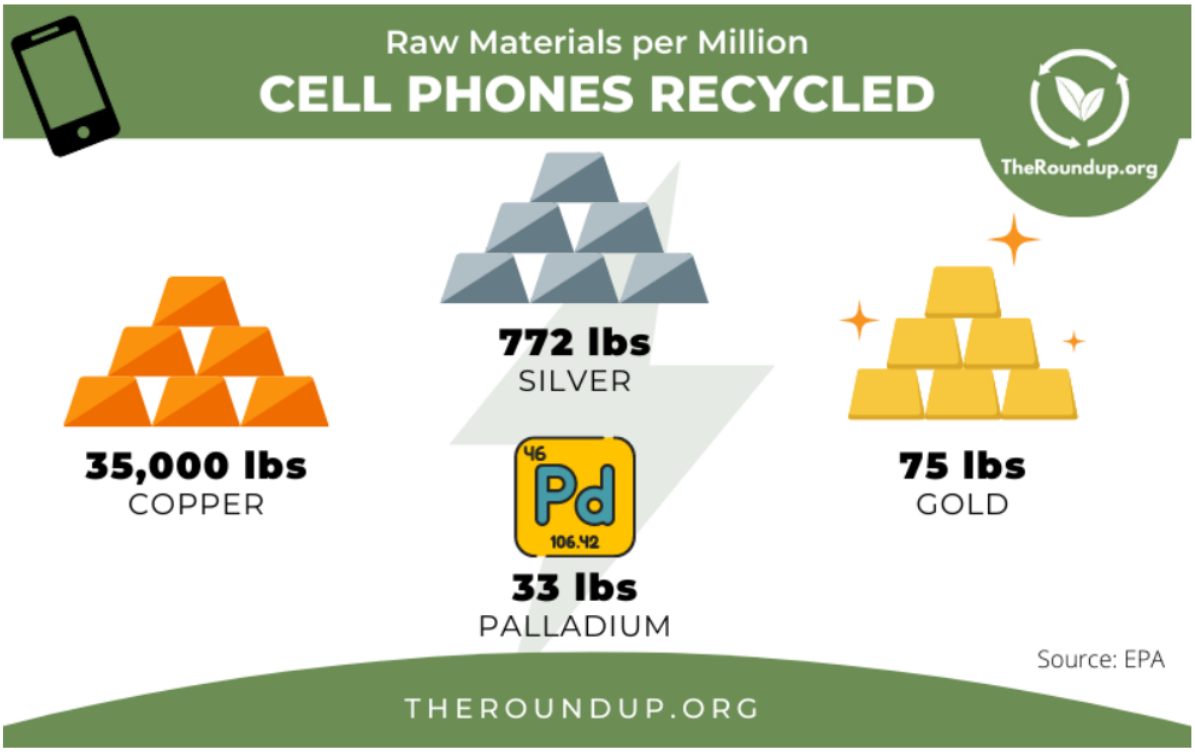

Figure 1

There are many resources that can be saved and re-used if electronics are disposed correctly for re-cycling. E-waste is also called the ''urban mine''. (WEE, 2019)

E-waste (or electronic waste) is the abbreviation of waste electrical and electronic equipment. There is also a definition of e-waste that has been agreed by the StEP Initiative. E-waste has been defined as: ''a term used to cover items of all types of EEE (electrical and electronic equipment) and its parts that have been discarded by the owner as waste without the intention of re-use.'' (Balde, 2020)

Bilitewski, argued that people learnt to dispose their waste around 9000 B.C.. According to him, environmental policy instruments are based on the polluter pays principle. The following policy includes: environmental fees, licenses, voluntary instruments, cooperative solutions, legislation, environmentally conscious government purchasing. The figure below represents expenditures and revenues under the influence of the environmental policy instruments. As discussions about waste have started back in the 1972, fourteen years later a rank order was introduced as the ''Waste Act''. This act was defined as: '' waste to be avoided, waste to be recovered and waste must be disposed in a manner that does not harm public welfare.'' (Bilitewski, 1994)

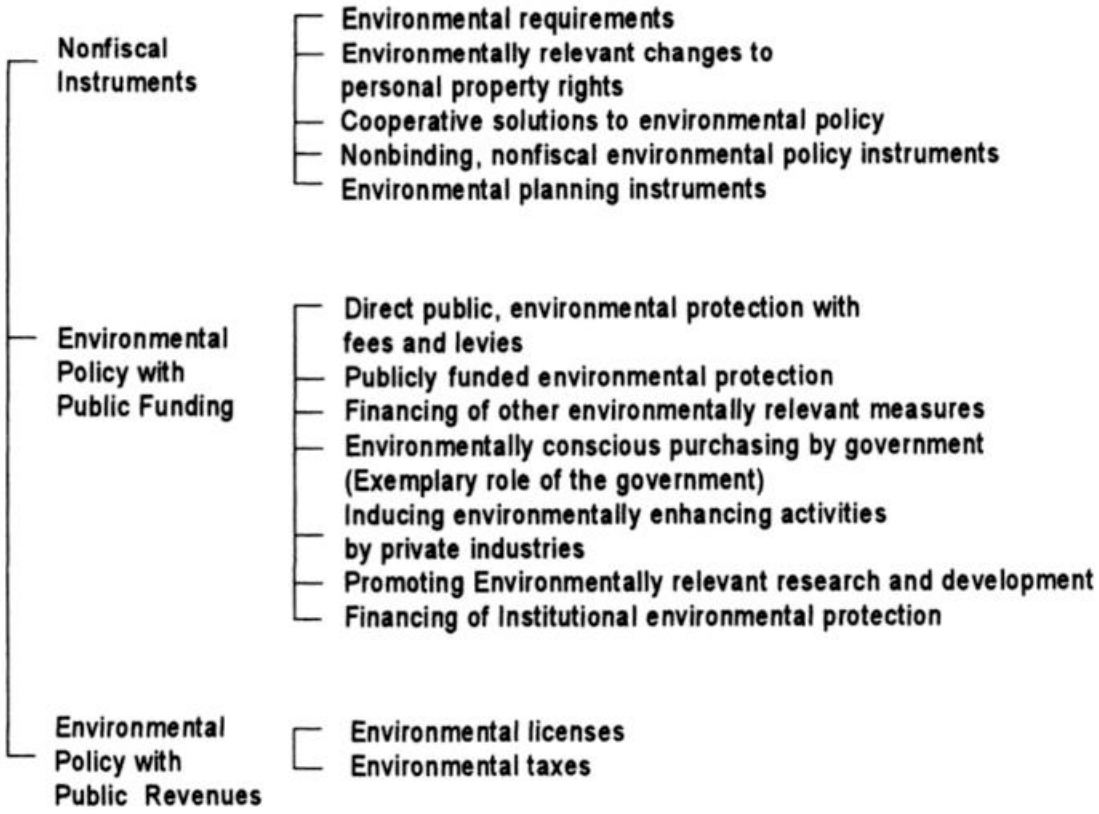

Figure 2

United Nations says that $10 billion of precious metals get dumped every year. The amount of electronic waste is rising very fast. It is rising three times more that the world population and people are not yet able to recycle it properly. In 2019, people from Northen Europe produced 22kg of electrical waste per person. This is a huge amount of waste that will contaminate the world with toxic substances that electronics contain. E-waste is a huge problem because the rates of e-waste grow very fast, while only little to no formal recycling exists. Moreover, low and middle income countries only have informal recycling which is not safe. They do not follow rules and do not wear personal protection equipment because of the lack of knowledge about the level of toxicity of those metals. The report also shows that in 2019, there was an estimation of 50 tonnes of mercury is lost every year due to informal recycling. Moreover, there are gases released from electrics like fridges and air conditioning equal to 98m tonnes of atmospheric carbon dioxide. This amount of gases is close to the national emissions of Belgium. Maria Neira, at the World Health Organization said that 1 in 4 children die because of the pollution. In 2018, the ITU set a goal to reach from 17% of electronic waste being recycled to 30%. It was said that this goal is not realistic at all. An argument to sustain

the above idea, is that from 193 United Stated only 78 have e-waste legislation in place. (Carrington, 2020).

A recent in depth study was conducted and the study shows that many countries did not reach the target of WEEE Collection. Three factors have been identified that make it difficult to reach the collection target as it follows:

- The waste flows outside the formal collection system
- Legislation regarding e-waste collection was implemented but not efficient. Some countries have implemented a mandatory handover of WEEE of the households. This legislation seems to create a successful mechanism, as the rate of collection has increased after it was implemented. In comparison, there are countries that use financial incentives to collect e-waste. The rate of collection in the countries that are using the second method have also increased, but the incentives are high and this method can not be applied in low economy countries.
- Economic or cultural factors (Balde, 2020)

Figure 3

The figure above shows that from all electrical and electronic waste, 2.1 kg/inh will end up in metal scrap sites and will not be declared as WEEE. Moreover, they will be treated at those sites which do not comply with the WEEE Directive requirements. 1.4 kg/inh of e-waste ends up in the waste bin and being incinerated or landfilled. No resources are being collected for re-use and huge negative impact on the environment. There are also illegal exports outside of the EU between 0.5 to 1.4 kg/inh. (Balde, 2020)

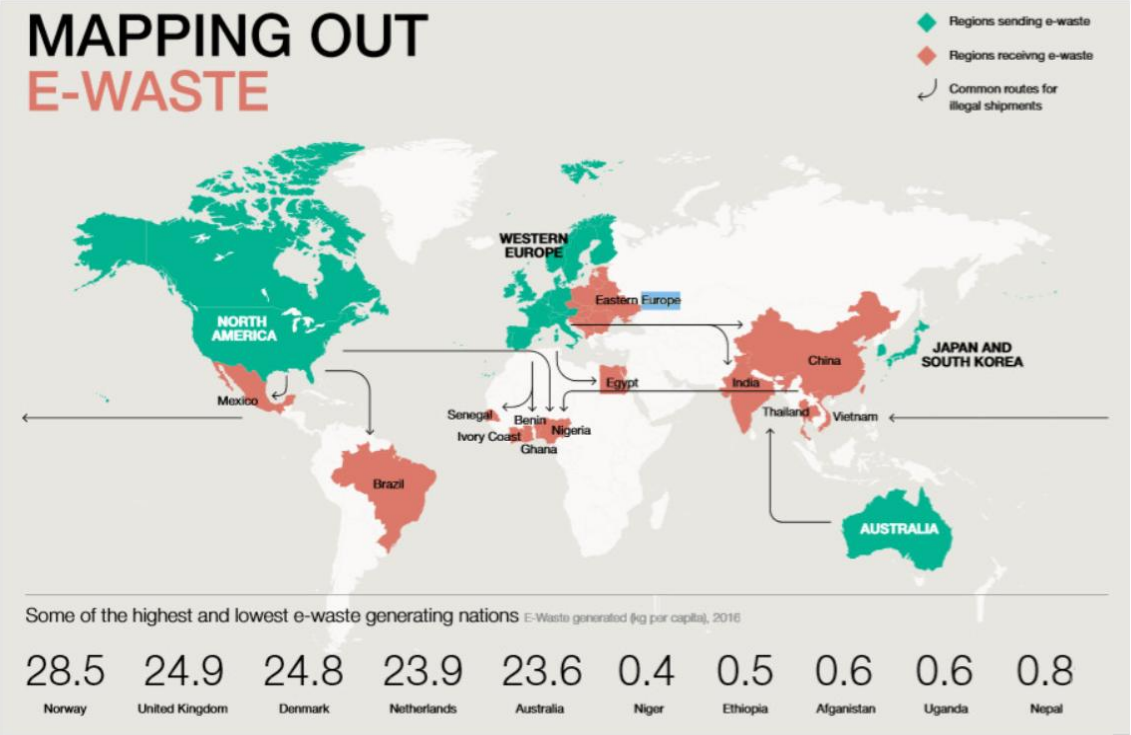

Figure 4

According to the International Electrotechnical Commision (IEC), in 2019 53,6 million tonnes of e-waste was generated. Moreover, the statistic shows that, by 2030, 74,7 millions of tonnes of e-waste will be generated. The amount of e-waste is huge and the impact that e-waste has on the environment is very bad. Furthermore, it is estimated that only one third of e-waste is handled by official channels and properly disposed. (IEC, 2021)

Another report shows that Asia was the biggest generator of e-waste in 2019 with a rate of nearly 25Mt. America has generated 13Mt and Europe 12Mt. The figure below shows the amount of generated e-waste and the amount of e-waste that was recycled properly. (Chanthadavong, 2020)

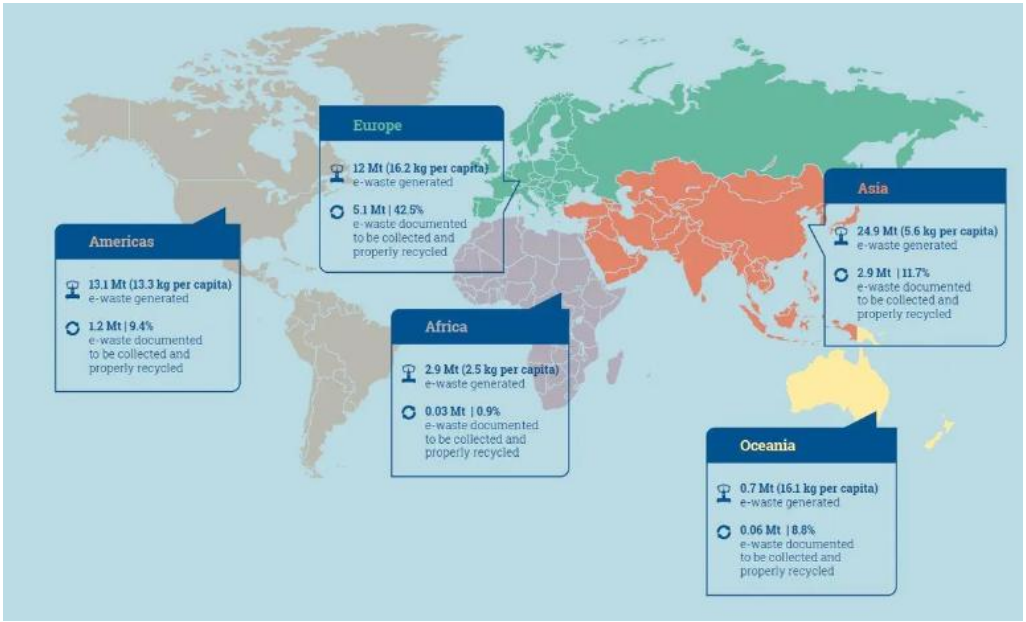

Figure 5

Only 17,4% of e-waste was collected and properly recycled in 2019. The rest of the e-waste was lost. Resources such as gold, silver, copper worth $57 billion were lost. They ended up burning or dumped. Action needs to be taken and world's climate experts have also announced that if no action will be taken the impact on the environment and health will be huge and irreversible. (Chanthadavong, 2020)

The pandemic was another factor that caused an increase in the rate of e-waste. Many people had to work from home and did not have the right equipment to work with and ended up buying new devices. As Arora states, ''new consumers, more junk''. It is expected even a sharper increase of e-waste. Legislation and mechanisms of proper recycling need to be implemented. There are many countries with low or middle income do not have e-waste management infrastructure. It is important that they implement the infrastructure because they are in the process of developing and there is an increase in demand for electricals and soon there will be an increase in e-waste. It will be easier if people will be educated to dispose e-waste properly from the beginning, and there will be no loss of resources. (Arora, 2020)

Impact on health

E-waste has also an impact on people's health. Electronics contain hazardous materials. When the components are extracted, worker's health can be affected if no PPE is used.

- For instance, arsenic is a hazardous material. This can be found in light emitting diodes and exposure to it can cause skin diseases and can also decrease nerve conduction velocity.
- Barium is another hazardous material and it can be found in spark plugs, fluorescent lamps and in CRT monitors. Exposure to barium can cause brain swelling, muscle weakness, damage to the heart, liver and spleen.
- Beryllium can cause chronic beryllium disease and skin disease.
- Flame retardants are also used in electronics and they release toxic emissions that can lead to severe hormonal disorder or cancer.
- Cadmium can be found in batteries. Continuous low level exposure can lead to kidney disease or bones brittleness. Moreover, if workers inhale it, cadmium present in the air will lead to lung cancer.
- Hexavalent chromium can be found in metal parts as an anti-corrosive coating on screws, rivets, bolts, frames, etc. This is very dangerous as it can be easily absorbed by the body and it will cause damage to the DNA.
- Lead can also be found in batteries and cable sheating. Exposure to this can cause: diarrhea, vomiting, convulsions, damage to the kidney, damage to reproductive system, anemia, increased blood pressure and miscarriage. Children are the most vulnerable to this, as it can cause damage to the nervous connections and brain disorders.
- Mercury is used for switches, thermostats, batteries and fluorescent lamps. Exposure to mercury can lead to damages to central nervous system and kidney.
- Polyvinyl chloride is found in the plastic components and it is considered carcinogen and toxic to reproductive system.
- Phthalate esters are a group of chemicals. They are used to soften the PVC and they can cause asthmatic problems and allergic reactions to children. (CIEL, 2015)

There are many hazardous components in electronics and they can cause serious health problems. There was a study conducted in China and there were 2 e-waste recycling points in different places. One of them was in Guiyu and it was an informal e-waste recycling place. The other recycling place was in Xiamen and it was a controlled environment. The outcome of the experiment was that

women living in Guiyu are four times higher risk of stillbirth compared to women from Xiamen. This is against the Human Rights. Article 6 of the ICCPR, states that "every human being has the inherent right to life. This right shall be protected by law. No one shall be arbitrarily deprived of his life." Moreover, Rights of the Child also states that "every child has the inherent right to life and that the survival and development of the child is ensured to the maximum extent possible". Article 24 of the Rights of the Child, also states that children have the right to enjoy the highest standards of health. Moreover, it is taken into consideration the dangers and risk of pollution. The International Covenant on Economic, Social and Cultural Rights under Article 10, states that special measures of protection to be taken on behalf of all children. The right to food was also established by the Universal Declaration of the Human Rights. Everyone has the right of an adequate living and including food and water. There are sites of e-waste recycling do not follow the rules and toxic components end up in the air, soil, etc. People will then eat vegetables grown in the contaminated soil and get ill. Furthermore, workers also have their rights. People who work in sites that do not comply to the rules have the right to remove themselves from danger. They also have the right to information and they should be informed about the chemicals they work with. They should be informed about their hazardous properties, precautionary measures, education and training. (CIEL, 2015)

United Nations Environment Programme made public an article in 2015. E-waste was an issue by that time already. In 2015, 90% of the world's e-waste was just dumped and not recycled. INTERPOL estimated the price of a tone on e-waste at $500 and a total of $12 to $18 billion annually. This report has also had a prediction of how many tones of e-waste will be generated by 2017. The forecast said that by 2017 there will be around 50million tones. The estimation was correct. Moreover, export of hazardous waste from EU or Organisation for Economic Cooperation and Development (OECD) to non-OECD countries is banned. However, thousands of tones will be shipped anyway. They are declared as second-hand goods. The smuggling techniques take place all over the world and needs to be stopped. The key destinations are poor countries mainly from Asia and Africa. For instance, in West Africa the main recipients are Ghana, Nigeria, Cote d'Ivoire and the republic of Congo. While in Asia the key recipients are China, Hong Kong, Pakistan, India, Bangladesh and Vietnam. (UN, 2015)

People's health is not the only thing affected by the hazardous elements. They have a negative impact on the entire ecosystem. The air is contaminated by the dust and large particulates created when electronics are being dismantled and shredded. Then workers that do not have PPE are directly exposed to the polluted air by inhaling it. This can cause lung cancer, chronic bronchitis and the entire respiratory system can be affected. The contaminated air will then affect the entire ecosystem by water quality, soil chemistry and plant species. Even if electronics will not be shredded but burnt, there will be fine particles released into the air. (Wilson, 2016)

The soil can be contaminated in two ways:

- Directly by disposing e-waste in landfills
- Indirectly by irrigation with contaminated water.

Contaminated soil will disrupt biodiversity and ecosystem balance. This will result in evolution of toxic plants that will be consumed by animals or human beings and their health will again be affected.

The water can also be contaminated in the same ways as the soil. People drinking the contaminated water, using the water for bath or eating fish from that water can face severe health problems. For

instance, there are places where water is undrinkable such as Mandoli, in India. The level of mercury in that water is 710 times the limit recommended by the Indian government. It can have a huge impact on the nervous, the reproductive systems and the organs. A very important thing to mention is that all hazardous substances do not degrade but they will persist in the soil/water/air and create an exposure risk even miles away from the contamination point. (Wilson, 2016)

It is estimated that 100 million people's health worldwide is affected by the toxins. In order to minimise the risks, there are a few steps that need to be taken. A proper formal electronic waste recycling process requires a longer process to obtain the resources that can be re-used without affecting worker's health or the environment. Because electronics are made of a variety of materials such as plastic, metal and glass there will be many steps to follow in order to conduct an efficient recycling. The recycling process can eighter be made by workers or mechanisms can be used for this process and no human being will be exposed to toxic elements. (Greentumble, 2015)

In a formal recycling process, the next steps should be followed:

- Collection and transportation. This step is a long and quite difficult step as it is still hard to find collection bins for the required materials.
- Sorting is the first step to follow, after electronics arrive at recycling points. Usually, electronics are being sorted into the specific technology categories. Not all devices are being made with the same materials. For instance, a TV will be made of different components comparing to a mobile phone. Because they have different elements, the recycling process will also be different and that is why it is so important to sort the devices before starting recycling them. Even mobile phones contain different materials. For instance an Iphone 4 will have different elements than an Iphone X.
- The next step is shredding and the materials have to be shred down into pieces
- Separation: in this step a magnet will be used to separate out the variations of the precious metals. After separation, the materials will be melt down and given another form that allows the material to be re-used. (Green Coast, 2022)
- There is also a water separation afterwards. This will separate plastic from glass. (Recicling View, 2022)

The informal recycling is usually made by waste pickers. They are individuals or organizations in the private sector that collect, sort, recycle, reuse or sell the materials collected. Informal recycling has a bigger percentage than formal recycling in most countries. Anyway, low or medium income countries still have a very low percentage of both formal and informal recycling. For instance only 36% of waste is collected in those countries. There is a figure below that shows the low percentage on electronic waste collection in low and medium income cities from China. The figure also shows that informal recycling has a higher rate than formal recycling. (Gutberlet, 2018)

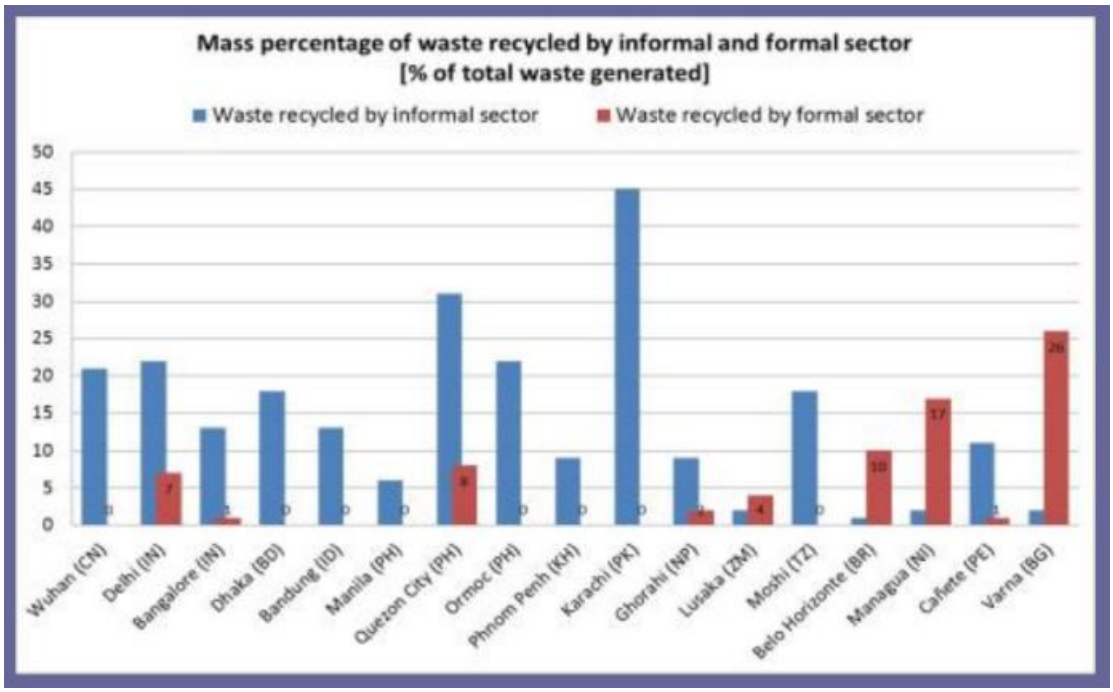

Figure 6

There are only a few cities across the countries that have formal recycling. The only option left is informal recycling. People who collect for informal recycling are usually poor people who only have this work option available. Their salaries are very low, they do not have access to state-sponsored or social protection schemes. They are exploited, they face intimidation and stigmatization. The number of people who collect waste informally is approximately 0.5 to 2% of the urban population. In other words, approximately 12.5 to 56 million people worldwide. Most of them are in China. China is also one of the biggest e-waste generator. Another countries where waste pickers number is high are India and Brazil. Moreover, a research conducted in Brazil, shows that waste pickers save the country to $0.5 to $1 billion every year. Waste pickers are vital players in the world economy. They save the planet and help the economy. Countries around the world need to improve waste management. Governments may implement formal recycling and encourage waste pickers to engage in dialogue with the Governments, in order to plan and implement a formal recycling system. Specific legislation and policies can be implemented to help micro-enterprises and associations develop. Awareness is another key thing in implementing a formal recycling. people need to be aware of the health and environment damages that e-waste can cause if not properly recycled. People should also be encouraged to appreciate waste pickers as they play a key role in the hole process. (Gutberlet, 2018)

Another way of improving the e-waste problem around the world is to educate people to re-use a device, to give it to another member of family or sell it for money instead of throwing it away.

Throwaway culture

This culture has a negative impact on society. The culture drives people to throw away many things such as electronics or any other goods. This culture is identified by specific behaviours such as:

- Buying things that are not needed
- Buying things just to keep up with the trend. For instance, many people upgrade their phone every year even if their old phone is fully functionable

- A very interesting behaviour is buying status symbol goods. For instance, many people buy Apple laptops as a status symbol without taking into consideration security, battery life or any other technical aspect. (Rexroth, 2022)

Throwaway culture itself can be thrown away. This culture encourages people to throw away fully functioning devices. For instance, Sonos is a tech company that wanted to make people buy new speakers. Sonos offered 30% discount for people who pushed a ''recycle mode'' button for old speakers. Even if the old speakers were functioning, once someone pressed the button their old speakers became disabled. There are many other similar situations where companies have tried to make people buy their new products. Apple and Samsung, were fined in 2018 for slowing down devices and force people buy new models of phones. They ''create'' a new model of phone every year. The quality of the devices is similar or maybe not as good as the old models, but the new design makes people buy them. this is also known as planned obsolescence. The negative impact of the throwaway culture is affecting the environment and economy. Many fully functional devices end up on landfills and contaminates the environment. Moreover, reports show that a good implemented formal recycling system could prevent one million tonnes of waste from ending up on landfills. The system can also save 14 million tonnes of CO2 emissions. (Tiefenbrun, 2017)

When should people consider replacing their mobile phone?

A mobile phone lifespan average is 2 to 4 years. The battery capacity of the most smartphones significantly decreases after 3 years. The hardware will be outdated and there will be issues when trying to access modern applications. There are smartphones that can last more than 4 years, but it also depends on the way it was used and looked after. In order to keep a smartphone for a longer time, there are a few factors that need to be taken into consideration, such as:

- The damage that the device has it is a crucial factor. If the phone has no damage and all components are functioning, then the phone may last longer. But if the phone has a crack on the screen it depends on how big the crack is. If the damage of the screen is only on a small area, then there is little to no impact on the device. When the device takes more than a quarter of the screen and there are dead pixels, then the lifespan of the device is affected by this. In most cases, screens can be replaced and phones will continue to function.
- Another factor to be taken into consideration is the health of the battery. All batteries have approximatively 300 to 500 charge cycles. This is calculated as 16 months of usage. After 500 charge cycles the capacity of the battery is low. The good thing is that batteries can be replaced.
- Outdated hardware and outdated software is another factor that can influence the life span of the device. Most smartphones are not able to run the up-to-date version of operating system after some time. Usually, Android phones have new system and security update at 2-3 years and Apple has the update at 5-7 years. (Chngin, 2022)

The approximate lifespan of each smartphone according to brand is:

- Smartphones lifespan is 2-4 years. They become non functional because of their battery or outdated hardware which is not able to support new versions of operating systems.
- Iphones estimated lifespan is 4 to 10 years. Iphones are described as durable phones. They become less functional because of their battery or when hardware can no longer support new versions of operating systems.

- Samsung phones have a lifespan of 3 to 6 years. The causes of becoming non functional usually is the battery, no longer functioning ports or outdated operating system.
- Huawei phones normally last between 2 to 4 years. The most common cause to replace a Huawei is the health of the battery. Their batteries become week after a couple of years of usage.
- Xiaomi phones are not as expensive as Samsung or Apple phones. Anyway, their lifespan is estimated to 2 to 4 years (decent lifespan for the low price). The most common issue that made the phone non functional was the touchscreen getting stuck.
- Oppo is another brand of phones and their lifespan is estimated to be between 2 to 3 years. (Chngin, 2022)

Tips to keep a mobile phone for a longer period of time are:

- Do not use all storage and RAM capabilities. This will cause lag times
- In order to protect the phone, a screen protector and a protection case will be needed.
- It is recommended to avoid software updates after 2 generations. After 2 generations, the new version of operating system will no longer be compatible with the hardware. Companies avoid making new versions of operating systems compatible with old phones because a lot of people will keep using their old phones instead of buying the newest models.
- Another tip for making the lifespan of a phone longer is to power down regularly. This will help the phone run more efficiently
- Use good charging practices. According to the report, it is a myth that by leaving you phone to charge for a longer period of time (for instance, over the night) will affect the health of the battery. But an interesting thing, is that charging the phone when the percentage is 25% or less it is bad, comparing to charging the phone when the battery is 75% charged. It is also mentioned in the report that by charging the prone at 25% will give you 500 fully powered charges, while by charging the phone at 75% will give you 2500 fully powered charges. In other words, the battery will last longer if it is charged for a few minutes on and off during the day, instead of fully charges.
- Another tip to keep a phone for longer is to avoid viruses and malware. To avoid viruses and malware, it is recommended to avoid downloading apps. If anyway the phone got a virus, the way to get rid of it is to reset the phone if it is an Android or to take it into safe mode and delete the offending app if it is an Iphone. (Chavez, 2022)

Artefact

The artefact is a prototype of a web app that can be developed in order to encourage reusing their devices or keeping them for longer. Because many people throw away their device just because they have little scratch or because the battery does not last as it used to be, the web app created will help people decide if to keep the device for longer. The aim of the app is to encourage people to keep their devices for as long as they are not completely damaged. In order to get a response, people need to answer a few questions about their device: for instance, ''For how long did you have the device''. all devices have a lifespan and it is easier to take a decision by knowing this aspect. Another question to be answered is ''what type of damage your device has?''. According to the answer given then the app will come back with a decision. For example, if you dropped the phone in water and you have had the device for more than its lifespan then it is more likely that you will get a decision to get a new device, but if a person with a new brand phone will want a decision because of a little scratch then it is more likely that they will be encouraged to keep their device.

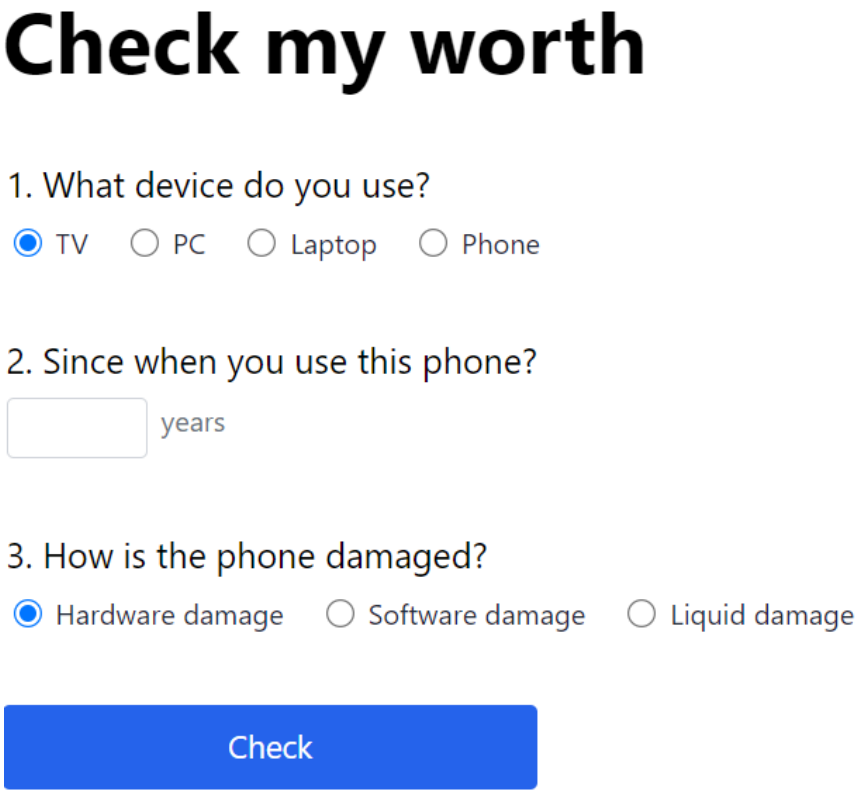

Figure 7

Figure 8

Figure 9

The artefact was created in Visual studio code using HTML, CSS and Javascript. The figures below represent some code snippets used to create the webb app:

```
                </div>
            </div>
        </div>
        <button onclick="checkQuiz()" class="px-32 py-2.5 text-lg bg-blue-600 text-white rounded mt-5">
            Check
        </button>
    </div>
</div>
<div id="good" class="w-full bg-white absolute top-0 hidden">
    <div class="w-full h-screen flex flex-col justify-center items-center">
        <h1 class="text-5xl font-bold text-green-600">You can keep your device</h1>
    </div>
</div>
<div id="bad" class="w-full bg-white absolute top-0 hidden">
    <div class="w-full h-screen flex flex-col justify-center items-center">
        <h1 class="text-5xl font-bold text-red-600">You can replace your device</h1>
    </div>
</div>
```

Figure 10

In the figure below there is a code snippet form javascript page.

C: > Users > stefa > Documents > assignment > JS app.js > checkQuiz

```
function checkQuiz() {
    // let device = document.querySelector("input[type='radio'][name=device]:checked").value
    // let period = document.getElementById('period').value
    let damage = document.querySelector("input[type='radio'][name=damage]:checked").value
    let good = document.getElementById('good')
    let bad = document.getElementById('bad')
    if(damage === 'liquid') {
        bad.classList.remove('hidden')
    } else {
        good.classList.remove('hidden')
    }
}
```

Figure 11

There are also three steps that companies can take to avoid electronic waste when not really needed:

- Reduce. This step encourages buying used devices instead of buying new devices all the time. If all enterprises will buy used devices this will reduce the amount of electronic waste.
- Repair. This step encourages repairing the existing devices. Many companies throw away devices just because their screen is broken or battery does not last as long as it used to. Both screen and battery can be replaced and the devices can be used for longer. If many companies and people will repair their devices instead of replacing them so many resources can be saved
- Recycle. In case the device can no longer be used, it can be replaced and the old device should be recycled. People and companies are encouraged to recycle the devices. Components of a device that enter a formal recycling process can be re-used without polluting. (Gibbons, 2021)

Geneva Environment Network has proposed a new circular approach for electronics. This circular vision for electronics includes designers, manufacturers, investors, traders, miners, raw material producers, consumers, policy makers, etc to have a role to play in reducing electronic waste. As the figure below shows:

- The designs of the devices should take into consideration durability of the device, reuse, safe recycling, and the most hazardous substances to be taken out or replaced if possible.

- The circular approach has also mentioned that policies should be implemented in order to encourage recycling. Moreover, all electronic waste should be treated by the formal sector and extracted materials to be kept at a high quality.

- Another factor of the circular approach is to reintegrate extracted materials into new devices.

- Repair devices and give them a second and even a third life. This approach encourages people and enterprises to repair their devices

- The last step of this approach is collection of end of life devices by formalized workers only. (Geneva, 2022)

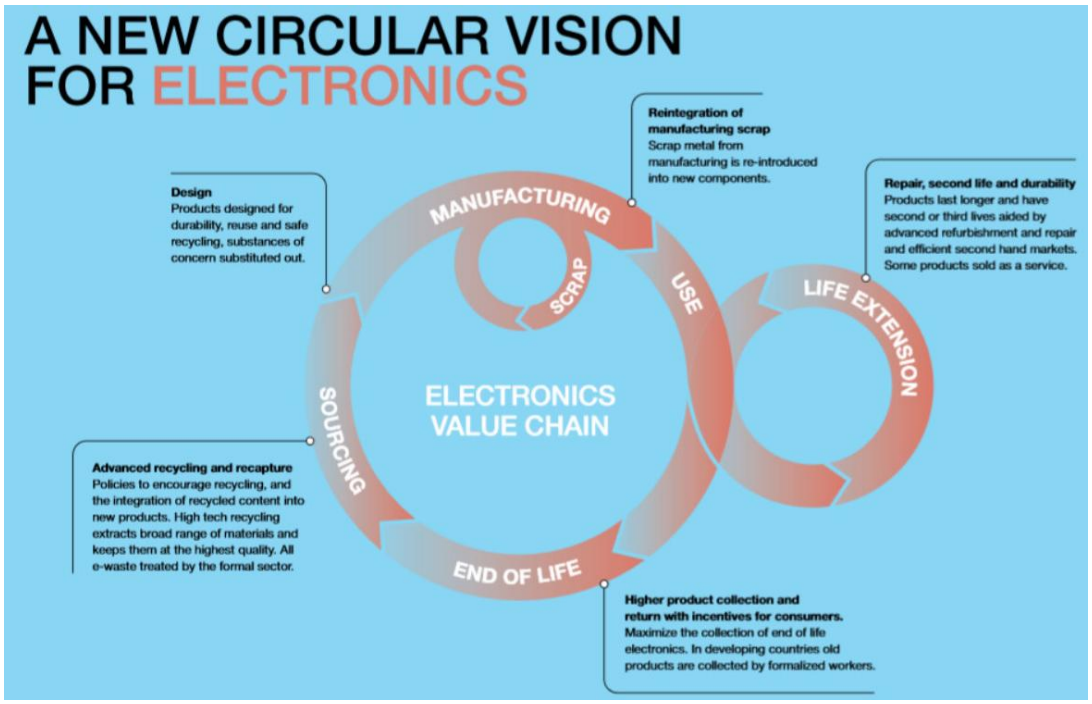

Figure 12

Legislation

A report shows that there is a lack of electronic waste legislation around the world. Governments should legislation, regulations and standards to be followed to ensure the economic benefits from recycling. (Ye, 2011)

In Europe it was developed the European WEEE Directive 2002. This legislation is supposed to help managing end of life electronics and improve collection and efficiency of recycling process. (Kumar, 2017)

Basel Convention was launched with the purpose of protecting human health and the environment from toxic elements such as mercury, lead, flame retardants, etc. The convention's main purpose is to control the movements of hazardous wastes and the way they are being disposed. As part of Basel Convention, PACE (Partnership for Action on Computing Equipment) was also launched. This is a partnership between governments, industry leaders, non-governmental organizations and other organizations to deal with refurbishment, recycling and disposal of end of life equipment. The Mobile Phone Partnership Initiative (MPPI) was also

launched and under this initiative, 5 technical guidelines were developed. Moreover, a E-waste Coalition was created by seven United Nations that have signed the letter of intent to collaborate, build partnership and support each other regarding WEEE challenge. (Geneva Environment Network, 2022)

In Japan, a law under Home Appliances Recycling Law came into effect. Under this law, people are supposed to send appliances such as refrigerators, air conditioners and washing mashines back to companies when they are end of life. This is a good measure of formal recycling. (Nair, 2021)

There is another act called, Electronic Waste Recycling Act 2004 (California). This act was used to establish a recycling program. Under this act, all consumers who bought a video display device, are supposed to return it. Moreover, when they have bought the device they paid an extra fee which was used to pay formal electronic waste recyclers. (E-waste, 2020)

ROHS stands for Restriction of Hazardous Substances and this act bans the use of hazardous substances for electronics and electrics. (E-waste, 2020)

Another standard that will help in organizing a reduced waste management cost, while protecting the environment is ISO 14001. This standard will guid on how to implement laws and regulations for a formal waste management. (ISO, 2022)

Forecast of E-waste Management Market

The global electronic waste management market size was valued at $49 million in 2020. It is estimated to rise at $143 million by 2028. It is estimated that in the future, 60% of the organizations and businesses are planning to allow employees to work from home. Work from home policies were implemented and all businesses and organizations are encouraged to adopt mobile devices. This will lower the rate of buying or adoption of IT equipment. The report also shows that in 2020, when the pandemic started and many people had to work from home, approximately 29% of desktop PC were abandoned in offices. Moreover, it is estimated that 23% of the PC will not be required next year. (Nair, 2021)

As electronics contain precious metals such as gold, silver, copper, etc. The metals have a high price but because the production is huge, there is a shortage of the metals and their prices keeps increasing. This has also increased the need to re-use the metals. Moreover, the cost of repairing a device is more than to get a new one. As people prefer to buy new devices instead of fixing the old ones, the forecast estimates a continuous rise in the electronic waste. In the report it is suggested the setup network of collection zones. (Nair, 2021)

The forecast also describes how Asia is considered to be the e-waste management market. This is a result of two main factors that are happening in Asia:

- Continuous innovations
- Decline in prices of products

Those factors have also influenced the lifespan of electronic devices. Moreover, there was an increase in people upgrading their devices as they have had an income increase as it is stated in the report. (Nair, 2021)

After the Covid outbreak, the number of electronics waste have significantly increase. Businesses took this opportunities to invest into recycling. For instance, Petonic Infotech has announced an investment of half a million dollar in Prometheus e-waste recycling. This investment's main purpose

is to minimise the electronic waste issue from India. The main two factors that keep recycling down in many countries such as India are: the high cost of recycling and not many collection zones. (Nair, 2021)

The first E-waste Echo Park was created in Delhi to help minimise the e-waste and to help mange electronic waste. The main purpose of this Echo friendly park is to recycle, refurbish and dismantle electronic waste but in a safe manner. This park is a great way of educating people about electronic waste recycling. This park was made in Delhi because this is a city that generates a huge amount of electronic waste and it is not recycled in a formal way. The park was made in Delhi to prove the beneficial to the city and to the citizens. The e-waste will no longer end up in the garbage and it will be recycled. The park will provide infrastructure, training and instruments. (Tentaran, 2022)

As mentioned above, India is facing a huge problem with electronic waste at the moment. Between 50 and 80% of America's electronic waste is sent to India and other countries. At the beginning of this process it was seen as a blessing. This sector has created 25.000 work places only in Delhi. The devices contain precious metals such as gold, silver, copper, etc. The negative thing is that children are also being involved into dismantling the units. Another negative thing is that both children and adults do not wear any PPE and are directly affected by the hazardous elements. There is little knowledge about the health implications of these workers. Most of the workers are not aware of the risks when exposing themselves without PPE to the toxic elements. Most of them did not have a training but they carry out dangerous procedures. (Kishore, 2010)

There are initiatives such as Extended Producer Responsibility (EPR), Design for Environment (DfE), Reduce, Reuse, Recycle (3Rs). These initiatives encourage the consumers to dispose their end of live formally and if the device can still be used these initiatives will encourage the consumer to use the same device, or sell it to someone who can use it, instead of throwing away a functional device. Moreover, these initiatives encourage people to adopt sustainable consumer habits. It is clear that countries like India will not follow this path straight away. Usually, only developed countries adopt this initiatives that easy. There are some factors that make it difficult for some countries to adopt this lifestyle so easy: for instance, lack of infrastructure represents an impediment in adopting these initiatives. Lack of appropriate legislation is another factor that makes it difficult for poor countries to follow this rules. Furthermore, the lack of description of the roles and responsibilities of stakeholders and institutions involved, was criticised. It is easier to follow the rules when everything is organised and everyone knows their responsibilities. (Manish, 2019)

It is estimated that 50 million tonnes of electronic waste was generated in 2018. Less than 20% of this amount of waste was recycled. There is no reports or evidence of what has happened with the other 40 million tonnes of electronic waste. It could have been burnt for resources recovery or it was illegally traded. There are no records of what happened with this huge amount of electronic waste. (Manish, 2019)

Records show that there is a 5 to 10 percent increase every year in electronic waste but the recycling rate are slowly increasing. Electronic waste keeps being shipped to countries like Peru, Ghana, Nigeria, India, Pakistan and China. They represent the biggest recipients of electronic waste at the moment. The situation in India, discussed above has been confirmed by the reports that show India ranking 177 out of 180 countries on the Environmental Performance Index 2018. India is at the bottom due to poor performance in the environment health policy and the high number of deaths due to air pollution. Moreover, children that work in these recycling centres spend between 8 to 10 hours extracting resourced from the electronics. Furthermore, it has

been discovered that four metro cities of India such as New Delhi, Kolkata, Mumbai and Chennai have their soil infestated with heavy metals. (Manish, 2019)

According to Widmer, ''environmental protection for health and aesthetic reasons is a luxury of the rich.'' He also mentions that in developing countries, morality is such a great problem. (Widmer, 2005)

Global Transboundary E-waste Flows

Recent studies have showed that the amount of electronic waste in 2014 will be double by 2030. This means that formal recycling should be put in place as soon as possible. Formal recycling includes transportation. There are many illegal transports of e-waste going on in the world. There is no track and no one knows approximately how many tonnes of e-waste are being transported illegally to other countries. The only thing that we know is that most of the illegally transported e-waste is labelled as electronics that can be repaired. This way there is no tax pay for transporting e-waste and no rules to follow. Recipient countries just keep collecting electronic waste. There are mountains of electronics that contain hazardous elements. Without knowing, their environment, as well as their health, is affected just because they live close to the e-waste mountains. Only The Basel Convention on the Control of Transboundary Movements of Hazardous Waste is the only global convention regarding this type of transports at the moment. This makes it difficult to bring all the countries to follow the same rules and to communicate data regarding this type of transport. For instance, it would be great to know an approximate amount of illegal transports of e-waste in order to know how to tackle this issue. Monitoring is a very good method of finding out about transboundary movement of e-waste. Good data quality is very important in finding the right solutions. All countries should be encouraged to submit national reports where to provide as much data as possible. A methodology should be put in place, in order to establish estimations of electronic waste illicit shipments. This report shows that in 2019, less than half of the member countries of the Basel Convention have submitted data regarding controlled electronic waste shipments. It is impossible to created consistent datasets when no data is available. (Balde, 2022)

Limitation to the analysis:

There are many limitations to this analysis such as:

- Basel Convention National Reports have many gaps
- False records are made as formal records, in order to hide illegal movements of e-waste
- Illegal transports of E-waste and no reports at all
- Shipment of wastes that hide electronics (intentionally classified as metal scrap)
- Shipments to trading hubs (Honk Kong or Dubai) are not representative of the final destination and the shipment can be counted twice which leads to inaccurate data
- Another limitation is represented by price analyses of the records in the trade statistics. There are many mistakes such as entering kg data instead of tonnage and this can lead to inaccurate data and unrealistic reports. (Balde, 2020)

As shown in the figure below, there are 1.8Mt controlled transboundary movements and 3.3Mt uncontrolled transboundary movements. The difference is too big and rates of controlled movements should be higher than uncontrolled movements. (Balde, 2020)

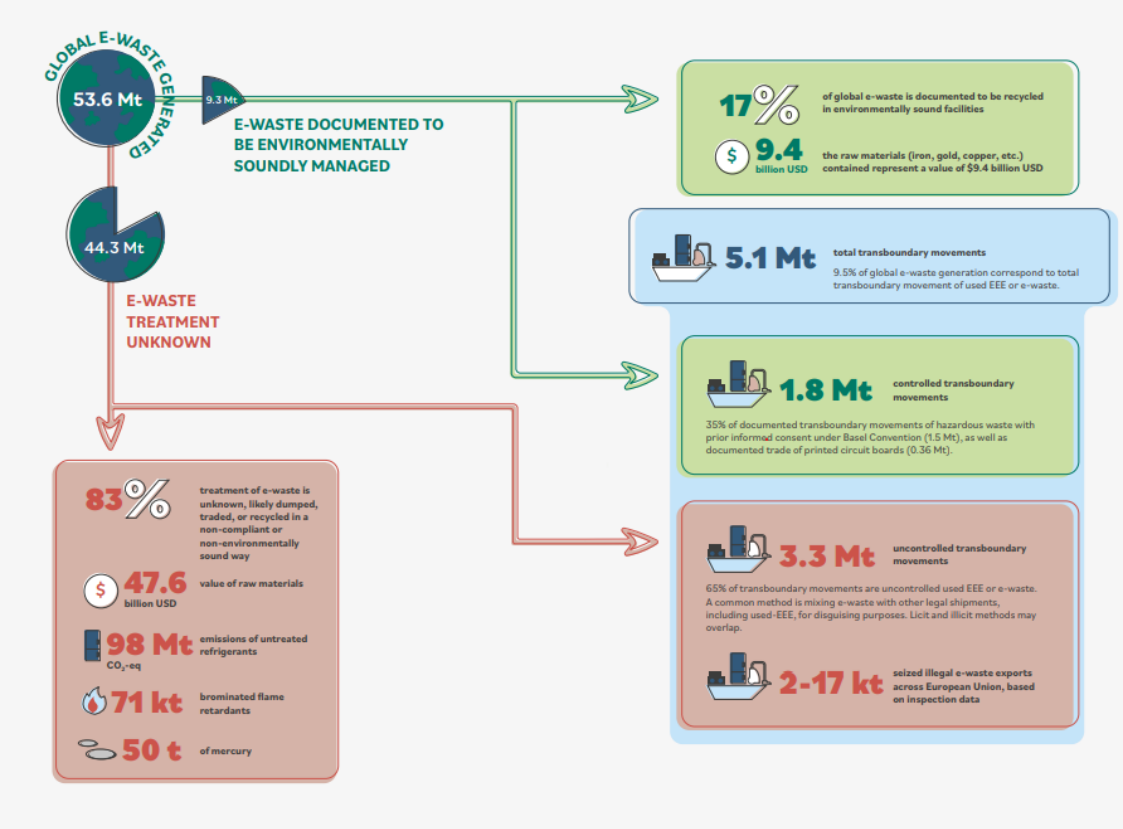

Figure 13

Regions like North America, Europe and East Asia have high income regions and they have developed e-waste management infrastructure. This is formal recycling, and those areas have the highest recycling rates. But even if they have a high rate of formal recycling, it is not enough for the amount of generated e-waste within those areas. The rest of the waste has to be transported to other recycling points. In comparison to these areas, there are low and middle income areas. they do not have developed e-waste management infrastructure but they import huge amounts of electronic waste causing damage to people health and damages to the environment. (Balde, 2020)

In this report it is stated that practices of recycling in low income areas are poor. For instance, the non valuable parts of the electronics do not go to further recycling, they end up on landfills and most of the cases without authorization to be left on landfills as some contain hazardous elements. The informal recycling is made as it follows: the electronic waste is left in inappropriate areas (close to residents, workers, schools), then the electronics are manually disassembled without using any PPE. The net step is collection of valuable materials and what is not reusable is normally dumped in open dumping sites and left there where they cause damage to the soil, air water. They have a huge negative impact on the entire ecosystem and causing serious health problems to people who leave around that specific area. (Balde,2020)

Africa

Statistics show that in Africa 0.03Mt of the 2.9Mt e-waste is being treated in environmentally sound facilities. Moreover, the number shows that Africa is a net importer and it is recognized as a strong informal recycling sector. The lack of proper legislation and finances to develop a formal recycling system results in e-waste being recycled in an inadequate manner and the non valuable parts of the

electronics end up being burn or left in open sites and causing direct damage to everything around. (Balde, 2020)

Africa provide very little reports to the Basel Convention. The lack of reports indicates a low capacity for environmentally sound treatment of e-waste and, another thing that Africa is trying to avoid, is reporting the presence of workers in this informal, inadequate sector. (Balde, 2020)

Another aspect presented in this report was ''cherry-picking". Cherry-picking represents a quick process of informal recycling, where only the valuable elements are being extracted and the non-valuable elements remain mixed and hazardous components remain neglected and end up dumped or burned. (Balde, 2020)

America

In America, only 1.2Mt of the 13.1Mt are documented as treated in environmentally sound facilities. In central and South America there is a strong presence of the informal sector. North America seems to manage well the electronic waste amounts. Moreover, North America is the only region on the continent that imports hazardous waste under the Basel Convention. The United States has signed the Basel Convention in 1990. There is a huge gap in the international goal. The United States made it public that they do not have enough domestic statutory authority to implement provisions. (Balde, 2022)

Asia

In Asia, 2.9 Mt of the 24,9Mt are being treated in environmentally sound facilities. In Asia the informal sector has a strong presence everywhere apart from high income countries. There is a huge competition in Asia between the formal recycling sector and informal sector. This competition between the formal and informal sectors, increases the risk that e-waste is ending up in uncontrolled dumping sites. There is also a huge production of electronic electronical equipment because in Asia production costs less. (Balde, 2022)

Europe

Europe generates 12Mt of electronic waste. 1.8Mt of the 12Mt are exported and report shows that 42% of the remaining electronic waste is formally recycled. 42% is not an excellent percentage, but comparing to other areas, this percentage shows progress. This percentage was obtained as a result of the advanced policy and regulatory framework. At the moment, Europe is both an export and import hotspot. Not all countries of Europe have developed laws and they have inadequate e-waste management infrastructure. But there are a few countries that have a well developed infrastructure. These countries also have well developed standards for pre-processing and end-processing of the electronic waste. Moreover, the report shows that there are more areas in Europe that have the capacity to treat hazardous waste. (Balde, 2022)

Western and Northern Europe import discarded printed circuit boards. Europe attracts imports from Southern Europe, Central and South Africa. It is also related that all regions of Europe have uncontrolled illegal exports. It is approximated a total of 1.3 Mt of exported e-waste. A tracking study from Basel Action Network took place. 134 trackers were secretly hidden in the e-waste exported from 10 European countries to take-back stations. The outcome of this experiment was that 6% of the tracked waste were exported to Ghana, Honk Kong, Nigeria, Pakistan, Tanzania, Thailand and Ukraine. More than half of these exports were illegal shipments. Another outcome of this experiment is that Europe is one of the main exporters of electronic waste. Acording to Blade, it is impossible to accurately estimate illegal electronic waste transports. (Balde,2022)

INTERPOL states that one of the main routes of illegal exports from Europe is from Western Europe to Western Africa and primarily to Nigeria. The shipments are not declared as e-waste but as used electronics that can be reused. In those containers there actually are used still function electronics and they get mixed with end of life devices. Moreover, INTERPOL stated that it is difficult to detect illegal shipments as they are not declared as electronic waste and others will even provide false reports of functionality tests. (INTERPOL, 2009)

Oceania

Oceania has a total of 0.7Mt of e-waste from which 0.6Mt is formally treated in environmentally sound facilities. Oceania is the second biggest e-waste generator per capita, with 16.1kg . Both Australia and New Zeeland account for almost all of their e-waste. In order to keep developing, the Australian Government has implemented a National Television and Recycling Scheme that offers collection and recycling for televisions and computers. Their target is 80% by 2026-2027. Australia has also banned landfilling of e-waste. (Balde, 2022)

Recommendations:

- To keep track of WEEE collections
- Find lost flows of WEEE
- Implement measures for reducing e-waste collection by metal scrap dealers
- Collaborate with local authorities to assess the E-waste in the waste bins
- Monitor re-use exports and identify illegal transports
- Implementing a mandatory handover of WEEE
- Run campaigns to educate consumers
- Implement a coordination body between producers, recycles, retailers, public authorities, customs, environmental inspection agencies and municipalities
- Set realistic rate target collection

Conclusion

In conclusion, e-waste is a huge problem worldwide. The rates of generated e-waste rise very fast while there is very little progress regarding formal recycling. Huge amounts of precious metals end up on landfills while other areas of the world mine for them as they are so needed. Laws and measures need to be implemented in order to reduce the illegal exports, and leaving e-waste on ladfills. Safety measures need to be implemented for people who work with hazardous elements. There is also a huge need of very strict protocols to be followed to achieve formal recycling. Education is another measure that cand be taken in order to spread awareness of the danger that people are exposed to when living by or working with hazardous metals. People and companies can also be encouraged to update and reuse their devices instead of throwing away things. Campaigns against throwaway culture or campaigns to encourage recycling are so needed.

References:

WEEE Forum, 2019, Too much e-waste ends up in the bin: *International E-Waste Day to focus on the role of consumers in improving rates of reuse, refurbishment and recycling*, viewed on [20/08/2022]. Available from: https://weee-forum.org/ws_news/too-much-e-waste-ends-up-in-the-bin-international-e-waste-day-to-focus-on-the-role-of-consumers-in-improving-rates-of-reuse-refurbishment-and-recycling/

Balde C., *et al,* 2020, *In-depth review of the WEEE Collection Rates and Targets*, viewed on [20/08/2022]. Available from: https://weee-forum.org/wp-content/uploads/2020/11/In-depth-review_WEEE-Collection-Targets-and-Rates_UNITAR_2020_Final.pdf

IEC, 2021, *IEC efforts to curb e-waste*, viewed on [20/08/2022]. Avaiablre from: https://www.iec.ch/blog/iec-efforts-curb-e-waste

Chanthadavong A., 2020, *UN reports global e-waste production soared beyond 53 million tonnes in 2019*, viewed on [20/08/2022]. Available from: https://www.zdnet.com/article/un-reports-global-e-waste-production-soared-beyond-53-million-tonnes-in-2019/

Arora N. and Farge E., 2020, *World's e-waste 'unsustainable', says UN report citing China, India and U.S*, viewed on [21/08/2022]. Available from: https://www.reuters.com/article/us-global-waste-un-report-idUSKBN243255

CIEL, 2015, *Human Rights Impacts of E-waste*, viewed on [21/08/2022]. Available from: https://www.ciel.org/wp-content/uploads/2015/10/HR_EWaste.pdf

United Nations Environment Programme, 2015, *Illegally Traded and Dumped E-Waste Worth up to $19 Billion Annually Poses Risks to Health, Deprives Countries of Resources, Says UNEP*, viewed on [20/08/2022]. Available from: https://www.unep.org/news-and-stories/press-release/illegally-traded-and-dumped-e-waste-worth-19-billion-annually-poses

Wilson De., 2016, *Impacts of WEEE (e-waste),* viewed on [20/08/2022]. Available from: https://ewaste.ece.uw.edu/students/impacts-of-e-waste-on-the-environment/

Green Coast, 2022, *Everything You Should Know About E-Waste Recycling Process*, viewed on [20/08/2022]. Available from: https://www.ecomena.org/how-ewaste-recycling-works/

Recycling View, 2022, *E-waste management and recycling process*, viewed on [20/08/2022]. Available from: https://www.recyclingview.com/e-waste-management-and-recycling-process/

Gutberlet V., 2018, *What is Informal Recycling?,* viewed on [20/08/2022]. Available from: https://www.researchgate.net/publication/326422916_What_is_Informal_Recycling

Rexroth, 2022, *What is a Throwaway culture?,* viewed on [21/08/2022]. Available from: http://www.indramat-us.com/what-is-a-throwaway-culture/

Tiefenbrun G., 2017, *Countering throwaway culture in consumer electronics*, viewed on [21/08/2022]. Available from: https://www.linn.co.uk/uk/blog/countering-throwaway-culture-in-consumer-electronics

Chngin R., 2022, *How Long Can A Smartphone Last? (With 6 Real Examples),* viewed on [21/08/2022]. Available from: https://valorvortech.com/how-long-can-a-smartphone-last/

Chavez H., 2022, *10 Ways to Extend the Life of Your Smartphone*, viewed on [21/08/2022]. Available from: https://www.lifehack.org/369959/10-ways-extend-the-life-your-smartphone

Gibbons S., 2021, *How Companies Are Addressing The E-Waste Problem*, viewed on [21/08/2022]. Available from: https://www.forbes.com/sites/serenitygibbons/2021/10/21/how-companies-are-addressing-the-e-waste-problem/?sh=4843813d7c21

Ye J., 2011, *E-waste management in developing countries through legislation and regulations: a case study of China*, viewed on [22/08/2022]. Available from: https://repository.lboro.ac.uk/articles/thesis/E-waste_management_in_developing_countries_through_legislation_and_regulations_a_case_study_of_China/9456023

Kumar A., 2017, E-waste: *An overview on generation, collection, legislation and recycling practices. Viewed* on [22/08/2022]. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0921344917300290

Geneva Network Environment, 2022, *The Growing Environmental Risks of E-Waste*, viewed on [22/08/2022]. Available from: https://www.genevaenvironmentnetwork.org/resources/updates/the-growing-environmental-risks-of-e-waste/

Nair A., 2021, *E-waste management market by application (Trashed and Recycled), Processed material type (metal, plastic, glass and others) and Source Type (Household Appliance, Consumer Electronics, and Industrial Electronics): Global Opportunity analysis and industry forecast, 2021-2028,* viewed on [23/08/2022]. Available from: https://www.alliedmarketresearch.com/e-waste-management-market

E-waste, 2020, *Current e-Waste Regulations in the US and Other Developed Countries*, viewed on [22/08/2022]. Available from: https://www.e-wasteonline.com/current-e-waste-regulations/

Tentaran, 2022, *India's First E-Waste Eco-Park in Delhi – Check Full Details,* viewed on [22/08/2022]. Available from: https://www.tentaran.com/e-waste-eco-park-in-delhi/

Kishore J., 2010, *E-Waste Management: As a Challenge to Public Health in India,* viewed on [22/08/2022]. Available from: https://www.researchgate.net/publication/47622078_E-Waste_Management_As_a_Challenge_to_Public_Health_in_India

Manish A., 2019*, E-Waste Management in India: Challenges and Opportunities,* viewed on [23/08/2022]. Available from: https://www.teriin.org/article/e-waste-management-india-challenges-and-opportunities

ISO Standards, 2022, *ISO 14000 family Environmental management*, viewed on [22/08/2022]. Accessible from: https://www.iso.org/iso-14001-environmental-management.html

Widmer R., 2005, *Global perspectives on e-waste,* viewed on [23/08/2022]. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0195925505000466

Bilitewski B., 1994, *Waste management*, viewed on [22/08/2022]. Available from: https://books.google.co.uk/books

Carrington D., 2020, *$10bn of precious metals dumped each year in electronic waste, says UN*, viewed on [24/08/2022]. Available from: https://www.theguardian.com/environment/2020/jul/02/10bn-precious-metals-dumped-each-year-electronic-waste-un-toxic-e-waste-polluting

Balde C., *et al*, 2022, *Global Transboundary E-waste Flows Monitor 2022,* viewed on [23/09/2022]. Available from: https://api.globalewaste.org/publications/file/286/Global-Transboundary-E-waste-Flows-Monitor-2022.pdf

Tiseo, I., 2021, Global E-waste – Statistics and Facts, viewed, [20/05/2022]. Available from: https://www.statista.com/topics/3409/electronic-waste-worldwide/#dossierKeyfigures

Prince and Izant, 2015, Precious Metals in Electronics, viewed [20/05/2022]. Available from:https://princeizant.com/news/precious-metals-in-electronic-devices

Ruiz A., 2022, Latest Global E-Waste Statistics And What They Tell Us, viewed [05/06/2022]. Available from: https://theroundup.org/global-e-waste-statistics/

Mcfadden Christopher, 2020, How Much Gold Is in Your Computer and How Efficient It Is to Reclaim It, viewed [02/06/2022]. Available from: https://interestingengineering.com/how-much-gold-is-inyour-computer-and-how-efficient-it-is-to-reclaim-it

Something borrowed, 2022, How Much Gold Is In A Computer, Laptop And Cellphone?, viewed [02/06/2022]. Available from: https://somethingborrowedpdx.com/how-much-gold-is-in-acomputer-laptop-and-cellphone/

Lubell I., 2018, Did you know your computer contains precious metals?, viewed [10/06/2022]. Available from: https://info.mayeralloys.com/ewaste-blog/did-you-know-your-computer-containsprecious-metals

Kramer K., 2012, Planned Obsolescence, viewed [10/06/2022]. Available from: https://www.sciencedirect.com/topics/computer-science/planned-obsolescence

Soke A., 2021, Built To Fail: 7 Examples Of Planned Obsolescence, viewed [10/06/2022]. Available from: https://durabilitymatters.com/planned-obsolescence/

TechReset, 2022, Why is recycling E-waste so difficult?, viewed [10/06/2022]. Available from: https://techreset.com/itad-guides/why-is-recycling-e-waste-so-difficult/

Interpol, 2013, INTERPOL operation targets illegal trade of e-waste in Europe, Africa, viewed [10/05/2022]. Available from: https://www.interpol.int/fr/Actualites-etevenements/Actualites/2013/INTERPOL-operation-targets-illegal-trade-of-e-waste-in-Europe-Africa

EIA, 2011, Scandal of UK's illegal E-waste trade exposed, viewed [10/05/2022]. Available from: https://eia-international.org/press-releases/scandal-of-uks-illegal-e-waste-trade-exposed/

Cotterell M., 2020, What is the current UK Legislation regarding E-Waste?, viewed [08/06/2022]. Available from: https://www.xpoitservices.co.uk/what-is-the-current-uk-legislation-regarding-ewaste/

Patil R., 2020, A comprehensive analysis of e-waste legislation worldwide, viewed [10/06/2022]. Available from: https://pubmed.ncbi.nlm.nih.gov/32162230/

Tiseo I., 2020, Countries covered by electronic waste legislation, policy, and regulation from 2014 to 2019, viewed [10/06/2022]. Available from: https://www.statista.com/statistics/1154905/projection-ewaste-generationworldwide/#statisticContainer

United Nations, 2022, Climate Action, viewed [02/07/2022]. Available from: https://www.un.org/en/climatechange/what-is-climate-change

Bourne E., 2022, E-waste: The next pollution problem, viewed [02/07/2022]. Available from: https://www.un.org/en/climatechange/what-is-climate-change

Miller A., 2022, How Soaring E-Waste Pollution Is Putting Lives at Risk, viewed [03/07/2022]. Available from: https://earth.org/e-waste-pollution/

United Nations Institute for Training and Research, 2022, Global transboundary E-waste Flows Monitor 2022, viewed [03/07/2022]. Available from: https://www.scycle.info/global-transboundarye-waste-flows-monitor-2022/

Graham E., 2020, 10 Shocking facts from The Global E-waste Monitor, viewed [03/07/2022]. Available from: https://s2s.uk.com/news/10-shocking-facts-from-the-global-e-wastemonitor/#:~:text=1.,weight%20of%20200%20Eiffel%20towers

Ruiz A., 2022, Latest Global E-Waste Statistics And What They Tell Us, viewed [03/07/2022].Available from: https://theroundup.org/global-e-waste-statistics/

Global E-waste monitor, 2017, Status of E-waste legislation, viewed [03/07/2022]. Available from:https://www.itu.int/en/ITU-D/Climate-Change/Documents/GEM%202017/Global-Ewaste%20Monitor%202017%20-%20Chapter%208.pdf

Leblanc R., 2020, E-Waste Recycling Facts and Figures, viewed [03/07/2022]. Available from:https://www.thebalancesmb.com/e-waste-recycling-facts-and-figures-2878189

Broida R., 2017, 8 ways to repurpose an old Android phone, viewed [05/07/2022]. Available from:https://www.cnet.com/tech/mobile/ways-to-repurpose-an-old-android-phone/