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Possibility of Recovery of Waste Electrical and Electronic Equipment (EEE) in Wineries: The Case of the City of Mahajanga

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Abstract

Electrical and electronic waste (WEEE) has become a global hazard, especially for developing countries, over the last ten years due to its 10% increase in three years (1997 to 2000). This research work is a contribution not only to raising awareness of the imminent danger due to the proliferation of electrical and electronic waste impacting on human health and the environment, but also to the decision making of decision makers to avoid the worst to face it. The capitaloftheBoenyregionandthetownofBelobakaarethestudys itesforthisresearchwork. The methodology adopted is both qualitative and quantitative. Its concretization in the long term requires the passage through a chronological order of the following activities: documentary research, raids, surveys, collection of various electrical and electronic waste at the level of the various treatment and transformation centers for the work of valorization allowing to make paving stones and tests were carried out. Several results were obtained from this research work, including: experimental methods were identified, three types of paving stones were obtained according to their composition and paving stone no. 3 was the most successful. The support of the local WEEE recovery centre and the popularization of the products are necessary to participate in sustainable development and the reinforcement of job creation.

Keywords: Pavers, Sustainable Development, Tests

1. Introduction

Electrical and Electronic Equipment (EEE) is equipment that operates by means of an electric current or electromagnetic field, or equipment for the generation, transfer or measurement of such currents and fields, designed for use at a voltage not exceeding 1000 volts in alternating current and 1500 volts in direct current. This term therefore covers a large number of devices of very different sizes and weights: washing machines, mobile phones, televisions, drills, vending machines, electronic thermometers, lamps and analysis tools (ADEME, 2019) [1].

Global WEEE production has increased by 9.2 Mt since 2014 and is expected to reach 74.7 Mt by 2030 - almost doubling in just 16 years. In 2019, Asia produced the largest amount of DEEE (24.9 Mt), followed by the Americas (13.1 Mt) and Europe (12 Mt), with Africa and Oceania coming last (with 2.9 Mt and 0.7 Mt respectively) (Vanessa *et al*., 2020) [7].

The production of WEEE in France was 1.5 million tons in 2000. Currently, the European Commission estimates that each European produces on average 40 kg of WEEE per year. The Commission welcomes the agreement on waste electrical and electronic equipment and the restriction of hazardous substances. Moreover, this ratio is expected to continue to increase rapidly in the coming years, given the significant growth in the production of this waste. Electrical and electronic waste is the fastest growing waste category. Its volume in Europe amounts to 6 million tons per year and is estimated to double in the next ten years' (Decottignies, 2014) [4].

Electrical or electronic equipment may contain various hazardous substances. Because of the presence of these substances, e-waste is generally considered as hazardous waste which, when improperly managed, can pose a serious risk to the environment and human health. The planned management and disposal of e-waste in each recipient municipality is therefore important for the long-term preservation of community and environmental health (Prodigy, 2020) [6].

In low- and middle-income countries, the infrastructure for managing WEEE is not yet fully developed or, in some cases, does not exist at all. As a result, the majority of WEEE is managed by the informal sector. In this case, it is often treated under poor conditions, with serious consequences for the health of workers and children who often live, work and play near WEEE management sites.

The environmental and health problems caused by the non-management of WEEE and the lack of previous studies have motivated this research, which has as its main objective the production of paving stones based on the target WEEE in the city of Mahajanga. This work was based on three main hypotheses, namely the recovery of plastics is a solution to environmental pollution; plastics can be good binders for the manufacture of construction materials and the production of quality paving stones from the mixture of sand and melted plastics can compete with concrete paving stones.

2 Materials and methods

2.1 Materials

Materials were used for the manufacture of paving stones based on WEEE mixed with sand, namely:

Thick plastics (speaker, subwoofer);

Fine plastics (plastics from WEEE such as TV fan shells, lamination, printer);

Working clothes (overalls, boots and masks).

- Sands
- Firewood
- Molds of different shapes
- Used oil
- Can
- Trolley
- Siphon
- Sponge

2.2 Methods

2.2.1 Identification of WEEE recovery channels in Mahajanga

The identification of WEEE recovery channels has been carried out. Although some recycling processes are still under development or under protection, several techniques for the recovery of materials or extraction of precious metals from WEEE are proposed in scientific articles. However, the analysis of the local sector and the economic and regulatory context of Madagascar was also essential in this identification. An observation grid was developed to collect information on prices, recovery techniques and the types of materials recovered locally.

Various methods have been identified to recover WEEE. Apart from the recovery of reusable materials after sorting and dismantling, the production of paving stones was carried out. The work was carried out with a specialist who processes plastic waste in Mahajanga, for one month, from 3 November to 5 December 2021. The performance test was carried out to assess the resistance of the produced pavers to impact and pressure until they were crushed.

Collections were made for the production of paving stones, following the formula (Vanessa *et al*., 2020) [7]:

$$\text{DEEE collection rate} = \frac{\text{total quantity of WEEE recycled}}{\text{total quantity of WEEE produced}} \text{ x } 100$$

2.2.2 Performance test and satisfaction test

The water absorption rate was determined. This is done by weighing the mass of the paving stone, followed by soaking it in water for 24 hours. The mass of the paving stone is then measured again after this operation. The normal water absorption rate ≤ 6 %. The absorption rate is calculated by the following formula:

$$\alpha = \frac{\mathbf{Mh - Ms}}{\mathbf{Mh}} \text{ x } \mathbf{100}$$

With: Mh: Wet matter; Ms: Dry matter

Twenty paving stones for each sample were tested by driving a Peugeot 205 car to determine their weight resistance. Customers were interviewed about their satisfaction with the finished products.

3. Results

3.1 Treatment methods for WEEE

Choice of materials

In plastic melting, both thin and thick plastics have been used. The following quantities are required for production: Total weight of plastics 68 kg, against 66.50 kg of sand. In batches of plastic bags, it is advisable to use fine plastics as binders to ensure good agglomeration. We will obtain 10 cobblestones for each cooking with the production time of 1h 40mn.

The following Fig 1 illustrates the proportion of raw materials (WEEE plastics and sand) for the three experimental tests.

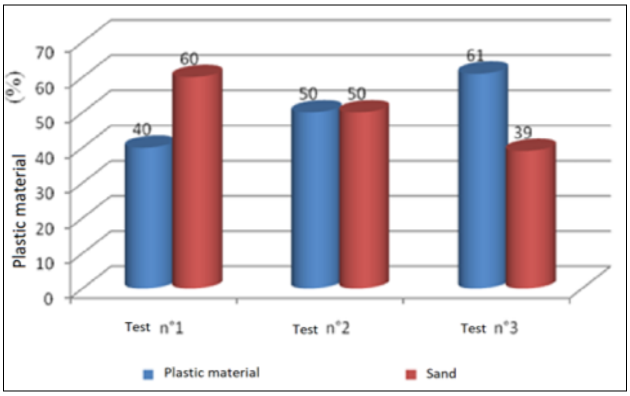


Fig 1: Proportion of raw materials used

The following Fig 2 illustrates the steps to be taken for the manufacture of paving stones from sand and plastic waste from WEEE.

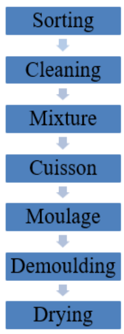


Fig 2: Paving stone manufacturing process

- The process is carried out and summarized as follows:
- We mix the (thick) plastic waste with the (thin) plastic waste

- We cook them in the drum cutter for 30 minutes and we will get liquids
- After that we pour in 1 bucket of 15 liters of sand and shake it all together
- We wait 30 minutes to get good results
- We put the molds in place

We will get 10 cobblestones at each firing.
The following Table 1 show the different tests carried out during the manufacture of the paving stones based on sand and plastic waste from WEEE.

Table 1: Performance test results

Tests	Composition	Quality	Observation
Tests n°1	Sand 2 buckets (28.5 kg) + 19 kg waste (Sand >comparedto WEEE plasticwaste)	Lowquality	Veryweak, brittle, fast firinganddrying time, sandypavingstones
Tests n°2	Sands 1 bucket (19 kg) + 19 kg waste (Sand = in relationtoplasticwastefrom WEEE)	Averagequality	Fragile, shock sensitive, not heavy duty
Tests n°3	Sand 1 bucket (19 kg) + plasticwaste 30 kg (Sand <compared to plastic waste from WEEE)	Good quality	Strong, usable, shock and weight resistant, saleable

The following figure shows the quality of the paving stones produced from three experimental trials.

a) Test paving stone n°1 b) Paving stone n°2 c) Test paving stone n°3

Fig 3: Quality of paving stones produced

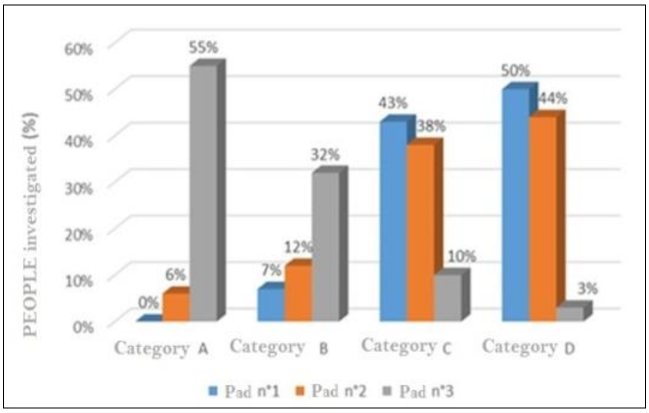
Table 2 shows the variation in the water absorption rate of the three samples of the tested pavers. The higher the plastic content, the lower the absorption rate.

Table 2: Water absorption rate

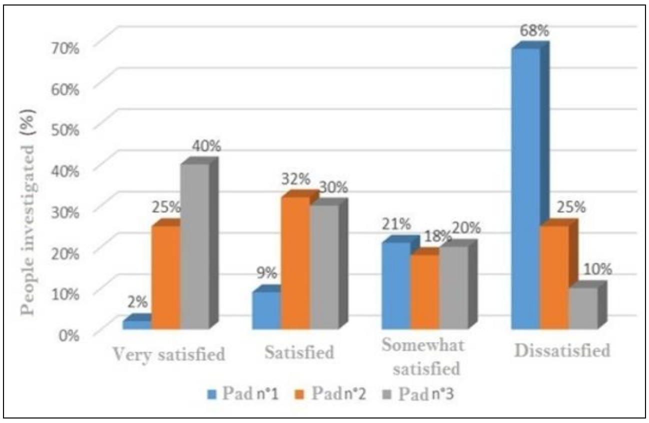
Parameter	Test 1	Test 2	Test 3
Plastics Content	40	50	61
Absorption rate	0.10	0.08	0.06

3.2 Results of the people's satisfaction test

The following Fig 4 illustrates: a) the percentage of satisfaction of the local population with the quality of the pavers produced. Paving stone n°1 was the least appreciated because of its fragility. On the other hand, paving stone no. 3, thanks to its hardness, is the most convincing; b) the percentage of the social class of the different categories on their appreciation in relation to the prices of the three types of paving stones.



People's satisfaction



Social class

Fig 4: Results of the satisfaction test

3.3 Discussion

Most African countries still do not have specific legislation on the management of waste electrical and electronic equipment. Few countries have published legislation on WEEE in Africa (e.g., Egypt, Ghana, Madagascar, Nigeria, Rwanda, South Africa, Cameroon and Côte d'Ivoire). However, the implementation of this legislation presents many cha+ llenges (Dimitrakakis, 2009) [3].
The particle size analysis of the sand shows that it contains very little clay. The modulus of fineness 2.86 shows that the sand is not very coarse, and not uniform. The mixing time is large overall and differs from trial to trial. This is due to the mixing system not being efficient and the dynamism of the staff differing from one day to the next.
In our case, losses also occur in the closing of the mixer and these losses are as much lower as the maneuver is dynamic. There are also losses of material due to the viscosity of the paste, the more viscous it is, and the more irrecoverable stocks are in the mixer. It should be recognized that often the fire used is often larger, which has led to the burning of the plastics (Hieronymi, 2012) [5]. Indeed, first of all, we witness a coagulation of the PP before it becomes liquid the more plastic the ratio contains, the greater the shrinkage.
Thanks to the very good adhesion between the fillers and the matrices of our products (excellent mix behavior), the test on the water absorption rate gave very satisfactory results. It varies from 0.08 to 0.10% (Claude, 2004) [2]. In our case, the

water absorption rate varies from 0.06 to 0.10%, which is also very satisfactory. The role of the binders is to ensure that the material does not absorb water. In addition, compacting with the press eliminates voids and pores that could store water. And we can say that the pressure we put on the mould is sufficient.

4. Conclusion

Waste collection in Mahajanga is currently far from optimal, but it should be remembered that this is a very recent and still unstructured sector that must face specific challenges. The same is true for its recovery, as the recovery of flexible plastics requires full control of the technical stages, costs and environmental impacts of the sector.

After examining the results obtained from the water absorption of paving stones made from plastic waste and available sands, namely river sand, the following conclusion can be drawn: cooling in the open air is recommended because with water, the paving stone often cracks immediately. However, the failure to comply with geometric tolerances disqualifies the product when compared to concrete blocks, as the moulds are designed without respecting the standard.

It should be borne in mind that plastics recycling should first and foremost produce low-cost goods for which there is a clearly identified need by local people. Plastic paving can compete with concrete in terms of both technical superiority and cost. The tests gave satisfactory results in terms of mechanical strength and porosity. The best test result was: compressive strength of 10.70 MPa for the 61/39 ratio paver; water absorption rate of 0.06%.

In terms of prospects, we believe that it will be necessary to: install a system to capture the smoke released during the combustion of plastics and treat the following pollutants: CO, NOx, SOx, etc: CO, NOx, SOx etc.; carry out ultraviolet tests for quality control: the destruction of the paving stones under the sun's rays and adopt a policy of popularizing the product because people do not know it until now.

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