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Potential for recycling of plastic material in household waste: A case study of a student dormitory in Kumasi, Ghana

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Abstract

The increasing world population, urbanization, as well as higher standards of living, have been identified as pivotal factors in higher production of waste. In urban Ghana, the official method to handle waste is to dispose it in landfills. The main aim of this investigation was to determine the potential of local recycling of plastic waste from household waste streams. The study was held in a student's dormitory in Kumasi. After extensive environmental education measures, the proportion of plastic fractions of 37 people's daily household waste, which could be recycled on site, was determined for 22 days using a waste separation system. The results show that with the help of separation and recycling of the study group's waste, in total it would be possible to save an average of 8.6 kg of plastic waste per month on landfills. The findings demonstrate how much valuable plastic waste could be saved from the landfills to obtain secondary raw materials and improve circularity of plastic material. The results of the study contribute to research on the composition of household waste in the urban areas of Ghana.

Keywords: Composition of Household Waste; Environmental Education; Waste Separation; Plastic Recycling; Waste Management

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1. Introduction

1.1. Current situation of waste production, waste management and their consequences

Currently, we can observe three global phenomena: increasing population, increasing urbanization and an increasing standard of living. These phenomena account for the main drivers for increasing waste production, including plastic waste (Rudolph et al. 2020, p. 91). This is seen in the global increasing amounts of produced plastic material and resulting wastes. (Geyer et al., 2017) In Ghana every day 12,710 tons of waste are generated (4.6 million tons per year), which means 0,47 kg/person/day (Miezah et al., 2015). Thereof about 1 million tons are waste plastics, 2 to 5% (22,000 tons – 55,000 tons) of that amount are reprocessed and the rest of it end up in waste dump locations, landfills, dumped in the sea or is going to be incinerated (Hervie et al., 2021). In the same survey it is estimated by the Environmental Protection Authority of Ghana that 2.58 million metric tons of plastics material are imported, 73% of this ends up as plastic waste (Hervie et al., 2021).

Associated with the growing amount of waste are various problems handling the waste. In Ghana, the state-regulated waste disposal largely relies on open landfilling. Landfills occupy and consume land, which is now a rare commodity in Ghana particularly near urban waste sources (Kaza et al., 2018 p. 82).

Landfills also pose health risks for humans and animals through pathogenic organisms and vermin, which facilitate the spread of disease (Chengula et al., 2015 p. 54; Asibey et al., 2019 p. 704). Due to improper landfilling of waste, ecosystems can be heavily contaminated, damaged, and degraded (Adzawla et al., 2019, p. 52). In developing countries waste management and recycling are often not considered as topics of high importance, which may be due to a lack of funding (Kaza et al., 2018, p. 77). Hence, waste collection and disposal in Ghana are often unreliable, and staff and equipment are inadequate (Addo et al., 2015, p. 81). Therefore, the existing infrastructure for waste disposal cannot stand the quantities of waste. In addition, there is an absence of a functional waste disposal system in rural areas. As a result, about two thirds of the Ghanaian population use illegal waste disposal options such as burning, burying, and depositing the waste in flowing waters, canals or anywhere else in the environment. The most important factors for the lack of developing working structures in waste management infrastructure can be seen in rapid population growth and urbanization, inadequate supply of waste bins, lack of waste transportation systems, low public awareness on the health, and weak enforcement of environmental regulations (Lissah et al., 2021).

Illegal waste disposal can have extensive negative consequences. The incineration of waste, including plastics, creates pollutants and particularly carbon dioxide as climate change driver (Adzawla et al., 2019, p. 51; Rudolph et al., 2020, p. 74). Besides its negative effects on the environment, smoke exposition is harmful to human health (Asibey et al., 2019, p. 704). Illegal burying and depositing waste can have a negative impact on the ecosystem by polluting and contaminating it. Moreover, non- or slow degradable materials such as conventional plastics occupy land (Rudolph et al., 2020, p. 74). Disposal in canals and flowing waters can lead to blockages which significantly increase the risk of flooding (Kyessi and Mwakalinga, 2009, p. 1). Furthermore, this behavior leads to the pollution of water bodies from the local to the global level because the flowing water can carry waste to the ocean. Lebreton and Andrady (2019) prospects, that from countries with mismanaged plastic waste regimes like Ghana is supposed to be there will be a rising amount of plastic waste entering the ocean. Subsequently, this can cause environmental pollution and contamination of water with, for example,

micro-plastics (Adzawla et al., 2019 p. 52; Rudolph et al., 2020, p. 74). Additionally, illegal waste deposits in open areas can contaminate surrounding soil, surface, and groundwater (Asibey et al., 2019, p. 704).

Considering the aforementioned negative consequences of waste disposal, measures against these should be taken. Against this background, plastic recycling could be a viable option to reduce the quantities of waste.

1.2. Recycling in Ghana

Recycling opens up opportunities to reduce crude oil consumption, carbon dioxide emissions, and waste quantities (Hopewell et al., 2009, p. 2115). Up to now, recycling has received only very little attention as an opportunity to reduce waste quantities (Oteng-Ababio, 2011, p. 551). From a social perspective, participating in the recycling process enables many people to participate in environmental and resource conservation. Emerging tasks in the recycling industry inspire entrepreneurship and create jobs, which can help improve social living conditions. The basic requirement for successful recycling, continued use, and reuse of waste is not to contaminate the garbage fractions with pollutants (Oduro-Kwarteng et al., 2016). Therefore, a separation system for waste would be beneficial. This would make the work processes easier and avoid unnecessary contamination. However, according to Oteng-Ababios' study (2011), attempts to persuade the population to separate waste have been unsuccessful so far. In his opinion, this is due to the lack of education of the population on the subject of recycling and environmental protection, as well as the lack of support through legally binding requirements. Some private recycling companies in Ghana are already established. Many of the companies rely heavily on physical labor. Additionally, there are only a few examples where recycling is carried out in a modern and progressive way, where suitable machinery is used (Acarp Ghana, 2015).

1.3. Current state of research

The current knowledge on waste quantities and waste composition in Ghana or, in fact, other countries south of the Sahara is poor (Chengula et al., 2015, p. 54; Kaza et al., 2018, p. 77). The literature research conducted in this study has not found any studies that provide information on different recyclable plastic fractions or studies with the same focus as the study at hand.

1.4. Aim of the study

The topic of the study was to determine the number of recyclable plastics of household waste of a selected test group. Hence, the research was conducted to answer the following question: "How high are the currently possible amounts of (according to current and local possibilities) recyclable plastic waste fractions in a student residence in Kumasi, Ghana?". The main goal was to find out how much plastic waste could potentially be recycled and would not end up in a landfill. This investigation should assess the potential for the improvement of separate collection schemes and risen awareness and reducing the mentioned environmental burdens in Ghana. For this study, only plastics have been examined which are known to be recyclable and convertible into secondary raw materials within the country. Especially the types of recyclable plastics in the test group, the quantity of each type and the influence of factors that influence the disposal of the plastic material were considered for analysis. Success factors influencing the implementation of improved collection system are

manifold (Maletz, 2017). The results of the study contribute to the knowledge gap on the quantity and composition of household waste in urban Ghana.

2. Methodology

The focus of the study and the conditions on site were the most important parameters that determined the study design. The main interest was to find out how much recyclable plastic waste was part of the household waste that could be separated by residents. It is important to mention that the actual amount of recyclable plastic fractions in household waste was not recorded. A distinction was made between different types of plastic, since, for sustainability reasons, it was considered important that local companies were able to recycle the separated fractions. This limited the study to the following four types of plastic: PET (Polyethylene terephthalate), HDPE (High density polyethylene), LDPE (Low density polyethylene) and PP (Polypropylene), which were collected in separate bin systems.

2.1. Study design

A waste separation system was used to separate the aforementioned plastic fractions from the rest of the waste. The participants of the study were supposed to sort their waste by themselves manually with the help of provided bins which were clearly signed as plastic collection system. This circumstance served as a prerequisite to record the actual potential of recyclable plastic fractions in household waste which could be achieved with the support of the population. The system was basic and easy to understand with prior instructions. In addition to the existing garbage bin for the household waste, a second smaller garbage bin was set up, in which the plastic fractions were to be disposed of. Both bins were labeled. On the entrance door of the kitchens, instructions on how and why one should separate recyclable plastic waste from household waste were placed. A total of three kitchens were available to the participants. Furthermore, an educational event was held before the start of the study, where the research and the waste separation stations were explained in detail. The educational event was a one-day workshop where basics of waste management, circular economy and recycling were introduced. During the educational event, the participants of the study learned from practical examples how to identify the recyclable plastic fractions and how to separate them. This opportunity was also used to provide detailed information on the protection of resources and the environment. All people who could not take part in the first event were instructed personally afterwards. All study participants received a leaflet including the most important information. Both the written instructions as well as the oral instructions were presented in English, which was the common language of the participants and the instructor. The study ran for twenty-two days. There were no incentives or rewards for separating their waste correctly.

2.2. Test group

The investigation was carried out in the "Ultimate Hostel" student dormitory on the top floor of the building named "Ultimate Hall". The examiner's residential location provided easy access to the examination site, making it possible to regularly observe, monitor, and evaluate the study. There were twenty-two inhabited rooms with a total of thirty-seven residents which were about twenty to thirty years old. Of the thirty-seven participants of the study, eight people were female and twenty-nine people were male students. Two of the

students had an international background and the rest were Ghanaian. All of them were able to speak English, though it was not necessarily their mother tongue. They were chosen as users of the Hostel as only random aspect. There were no further criteria or exclusion criteria. The test group therefore does not represent a normal composition of the Ghanaian society, cause only persons of younger age and a willingness of living in multi dorm accommodation are covered, which is considered during the results interpretation section.

2.3. Data collection

The examination of the students' household waste was carried out from November 12th to December 4th, 2019. All bins for plastic waste were emptied every day at around ten p.m. and the disposed fractions were separated and counted manually by number of pieces and weight. The type of determination was done by the recycling labels on the items and personal experience by the authors and supporting participants. By thorough and careful measuring and counting and the comparable small number of items no further data quality control was applied. To support the evaluation of the data, a logbook was kept in which observations, such as contaminated plastic waste or recyclable fractions in the landfill, were documented. These observations were used to evaluate the results.

3. Results

The overall results convey that several of the test people have followed through with the waste separation. This was demonstrated by the number of correctly separated plastic fractions. The study group correctly separated 6.2 kilograms of plastic waste from the main waste within the period of 22 days. This amount calculates 231 grams of plastic waste per person per month and 7.6 grams per day. As shown in Figure 1, the largest share of waste consisted of PET waste and was around 4.17 kg (5.8 kg per month), followed by LDPE with around 1.46 kg (2.1 kg per month), followed by HDPE waste with 0.40 kg (0.5 kg per month) and PP waste with 0.16 kg (0.2 kg per month). The distribution of the quantities is probably due to the frequency of the products used.

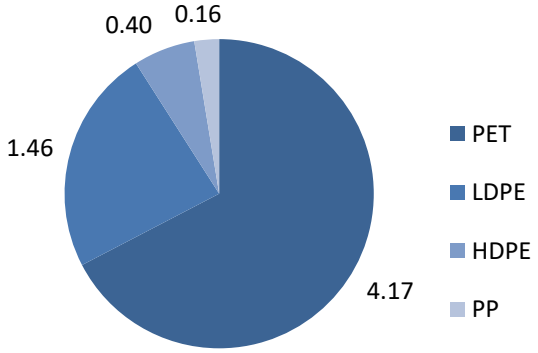

Figure 1. Weight distribution of the separated plastic fractions in kilogram(s) for 22 days

The maximum value of waste separation was determined shortly after the first round of instructing the participants personally about recycling on day three and four. It was perceived that the willingness to separate waste decreased over the entire period of the study which can be understood from the trend line for the total amount of separated plastics (see Figure 2). This could be due to different causes, such as disinterest, laziness, staying in habit, language barriers and missing information. Explained can this by the missing intrinsic motivation in participation in separate collection schemes. People tend to follow new suggestions in their life in the first moment by curiosity and the understanding of the necessity in changing environmental behavior. But with longer duration people fall back to their old perceptions and habits. Therefore, it is necessary for the case of collection behavior to establish a steady and regular awareness building mechanisms in society. In other studies where separate collection schemes were implemented observed similar developments over time (Maletz, 2017). In the for mentioned publication there is a summary of challenges and suggestions to overcome the lack of participation in separate collection systems.

A similar project at a Ghanaian University come to values of 80 grams per day and person of plastic waste generation (Asare et al., 2021). So, using this amount for a similar group of people (student group), there was a share of separated plastic waste of 10%, which can be considered as a realistic approach for prospection of amounts when planning an implementation of a separation systems in certain groups or regions.

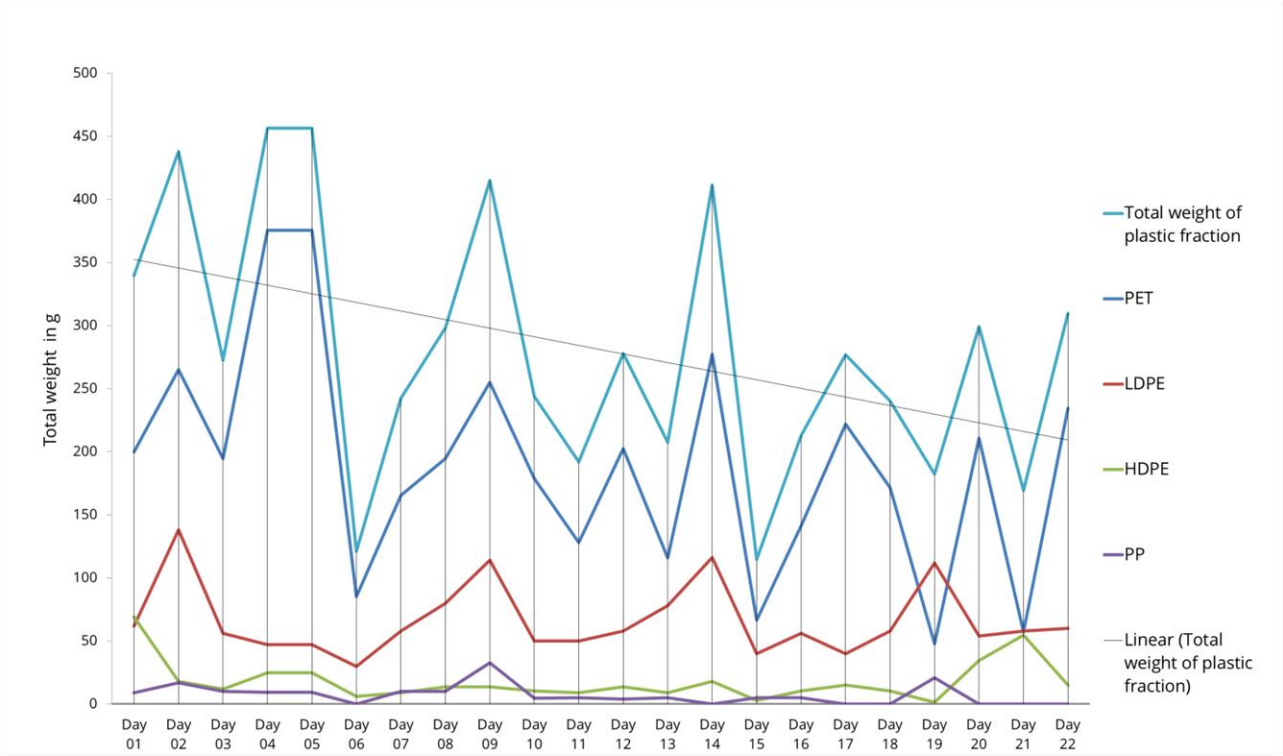

Figure 2. Daily total weight of the separated plastic fractions and all plastic fractions over the course of the study in gram(s)

4. Limitations

It must be clearly emphasized that the test group was very small due to the working conditions, which considerably limits the representativeness of the study. In addition, the structure of the study only examined a small and specific user group. Therefore, the study only represents the average behavior of a small part of the population. In order to obtain significant results, a higher sample size and a longer study period is needed. Statistical tests have not been applied because of the low number of cases. Confounding variables related to possible response-bias have not been considered. The approach in this small source separation project was just set up as orientation for tendencies and define further research directions.

Furthermore, different groups of the Ghanaian population should be included. Taking more variables into consideration such as age, occupation, income, and class would allow the results to deliver a more precise pattern of population behavior regarding waste separation. Older people tend to follow separation requirements better than younger people, if they have enough experience with separate collection schemes in the past years. Younger people can adopt easier to changes, especially in waste and environment related behavior.

5. Conclusion

The research paper has the purpose to demonstrate that the current state of research on the potential of recyclable plastic fractions in household waste has not yet been sufficiently investigated. The present study attempted to fill this knowledge gap. Nevertheless, there is a need for further research in this field. The results could serve to convince decision-makers to introduce waste separation and recycling in Ghana. Moreover, the research and the study results could prove that waste separation and recycling is already possible in Ghana. Parts of the Ghanaian population already support the idea and are willing to contribute actively. This was especially the case after substantial education on the topic. So, for example, if one were to introduce waste separation at the student's dormitory on the second floor, one could assume that the waste of the student group examined could save an average of around 8.6 kg of plastic waste per month on landfills.

Generally spoken the herewith shown aspects of improving recycling and decrease plastic pollution in Ghana are started to take action. Several plans and strategies are to be implemented currently (Kwansa, 2021). The study and the paper have the goal to further increase the awareness of the topic among science and society.

6. Recommendations

Landfills in Ghana are rapidly increasing, occupying valuable land and threatening the environment. To reduce the amount of waste on these sites, waste separation and subsequent material recycling could be particularly helpful. Also, landfilled and otherwise inaccessible recyclable plastics are equal to the loss of limited resources. In Ghana, many plastics can already be processed into secondary raw materials. Therefore, it would be important to introduce a simple separation system for the population and enforcing it with legal requirements. In addition, a public recycling scheme should be implemented. The enactment and implementation of regulations and laws in the field of waste management may be beneficial. The execution of legal punishment

for illegal waste disposal could prove effective. The cost regulations for waste collection and disposal could partly be sponsored by a fee paid by the manufacturers of plastic products.

In November 2021 the Ghana National Plastic Action Partnership released "A Roadmap for Radical Reduction of Plastic Pollution in Ghana" which addresses these challenges and offers further solutions (NPAP, 2020). As the research pointed out, the increased level of education and the knowledge of environmental and resource protection have a positive influence on the willingness to actively participate in waste separation and recycling. Therefore, the population of Ghana should be repeatedly educated and sensitized on the subject.

From a social perspective, taking part in the recycling process empowers people to participate in environmental and resource conservation. The development and improvement of the recycling industry promotes entrepreneurship and creates jobs, which can help improve social living conditions in Ghana. Improving working conditions during current recycling processes by reducing health risks could also have a positive impact on people's living conditions.

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