European Journal of Social Sciences Studies
ISSN: 2501-8590
ISSN-L: 2501-8590
Available on-line at: www.oapub.org/soc

DOI: 10.46827/ejsss.v7i6.1363 Volume 7 | Issue 6 | 2022

CHALLENGES OF SOLID WASTE SEGREGATION AT UNKI PLATINUM MINE IN SHURUGWI, ZIMBABWE

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Abstract:
Waste segregation at the source, which is a pre-requisite aspect in waste management challenges, is a concept that mining sectors in Zimbabwe are yet to completely appreciate and put into practice on a broader scale. The accumulation of solid waste has become a global challenge in various mining industries. Despite the efforts of Unki Platinum Mine in environmental management participation in solid waste segregation at Unki Platinum Mine is still limited. Since the organization needs to accomplish its aim of zero waste to landfills by 2030, it is critical to encourage source separation practices among its personnel. There is a need to recognize the issues at a general employee level in order to propose appropriate suggestions for enhancing solid waste segregation at the source. The goal of this study was to look into the issues of solid waste segregation at the source at the Unki Platinum Mine in Shurugwi. Several departments at the mine that create significant solid wastes were chosen to participate in this investigation. Within the Mining, Concentrator, Human Resources, Mineral Resources Management, Engineering, and Environmental, Health and Safety and Quality (SHEQ) departments, questionnaire sets were distributed to the targeted audience. This research included a variety of data collection methods, including questionnaires, observations, and guided interviews. The problems with solid waste segregation at the source have been highlighted. These include a lack of adequate awareness and enough receptacles, especially in underground working locations, and failure to recognize substantial waste in sections, as well as behavioral tendencies and indifference on the part of most employees toward solid waste segregation systems. More recyclable waste is being dumped into landfill as a result of poor solid waste segregation at the source. The study findings revealed that inadequate receptacles, trash collection equipment, and a lack of effective instruction to staff are likely infrastructure hurdles to correct solid waste segregation at the source. Solid waste segregation at the source can be achieved by providing adequate receptacles, motivating

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personnel with incentives, and implementing appropriate instructions, awareness and initiatives.

Keywords: waste segregation challenges, Unki platinum mine, Shurugwi, Zimbabwe

1. Introduction

The study examines the difficulties that come with solid waste segregation at the source. It used a case study methodology, focused on the Unki Platinum Mine in Shurugwi. Solid waste segregation at the source is a waste management practice that involves separating and sorting different materials found in solid waste at the point they are generated in order to promote resource recycling and re-use while also reducing the amount of waste that needs to be collected and disposed (Eugenia, Bennagen, Nepomuceno and Covar, 2002). The culture of waste segregation at the source, which is a prerequisite aspect in effective and sustainable waste management is a concept that is yet to be fully appreciated and implemented on a broader scale. Solid waste accumulation, therefore, has become a global problem of the day (Shrikant, 2008). Any action, such as meal preparation, sweeping, cleaning, burning fuel, gardening, and recreation generate solid waste (Medina, 2010). On a daily basis, large volumes of various products are generated, utilized, and discarded as garbage, causing garbage and waste disposal to become a huge ecological issue (Cointreau-Levine, 2001). Only a fifth of the estimated 11.2 billion tons of solid waste collected and disposed to landfills each year is diverted from disposal to recycling and re-use processes. Even with high rates of valuable materials such as cardboards, plastics, glass, and metals in municipal solid waste (up to 50% in underdeveloped countries), landfills are used to dispose them off with no recovery. This is due to the fact that waste separation at the source is rarely practiced (Kneeland and Knutson, 2012). Other unique solutions may be required for activities such as recycling, but the separation of solid waste at the source is the starting point (Ehrampoush, 2005). Limited resources in garbage collection and lack of regularity in the collection of segregated waste and receptacles are blamed for this ineptitude in solid waste segregation at the source in metropolitan centers, institutions, and mining industries around the world (Ogwueleka, 2009).

The main challenges to adopting source separation of Municipal Solid Waste (MSW) in urban areas, according to Towhid, Haidar, Mohammad, and Hamid (2018) are a lack of citizen accountability, insufficient information, and the expectation of receiving rewards. As a result of the lack of segregation, recyclable and reusable solid waste has ended up in landfills. This indicates that adequate solid waste segregation at the source is hampered by a number of factors. It is critical to practice and maintains the highest level of solid waste separation at the source, according to Mangundu, Eric, Makura, Mangundu, and Tapera (2013), for an integrated solid waste management program to be successful. The low levels of trash separation at the source support conclusions of Wilson (2007) and Simon (2008) that, while separation at the source is critical for solid waste reduction, it is not generally practiced in cities of the global South. Because of the mixing

of solid waste, recovery, reuse, and recycling has become difficult and impractical. It is worth looking into the issues that developing countries face when it comes to limiting solid waste segregation at the source. Trash separation has expanded in industrialized countries as a result of successful waste-sorting equipment interventions. They have effective waste management systems in place and employ cutting-edge management approaches. Germany, for example, employs Enhanced Resolution and Mobile Sorting, which are proven to be very effective in reducing waste and increasing the likelihood of recycling and reuse (Srivast, 2013). Most European citizens, according to Capel (2008), know that effective recycling requires waste sorting, hence waste sorting, particularly at the household level, is becoming increasingly crucial. Separating the various elements contained in the garbage is critical for recovering useful resources, reducing the amount of waste sent to landfills, and allowing recyclable products to find new life. In developing countries, solid waste is rarely separated and recycled, instead, it is being dumped into landfills (Babu et al, 2009). In most emerging and transitional economies, solid waste management is seen as one of the most pressing and critical issues affecting city governments (UN-Habitat, 2010).

A more comprehensive technical picture of sustainable and integrated solid waste management (SISWM), in which waste minimization, source separation, sanitary storage, efficient collection and transportation, compositing, incineration, and sanitary landfill disposal all complement each other in an economically viable, socially acceptable, and environmentally friendly manner, remains elusive (UN-Habitat, 2010). Solid waste segregation into different components is an important step toward a more sustainable and integrated waste management system. The mixed nature of trash, with plastics, metals, and raw faecal matter, is still a serious issue, particularly in low-income areas (Boadi and Kuitunen, 2004). There are limited resources for waste collection in poor nations, as well as a lack of regularity in the collection of separated waste and bin storage capacity. Lack of waste segregation at the source encourages poor people to scavenge for recyclables, refuse materials, fuel, and food on waste sites. Due to a lack of solid waste segregation at the source, the health and environmental dangers linked with informal salvaging on landfill sites have escalated. The complete range and character of solid waste segregation at the source are not properly handled, resulting in solid waste management is a major global issue (Boadi and Kuitunen, 2004). As a result, it is critical to comprehend source separation constraints. The purpose of this study is to identify obstacles in solid waste segregation at the source and to provide alternative approaches for promoting source separation in order to achieve sustainable and integrated solid waste management. Solid waste management becomes a concern in the mining industry, just as it does in many other businesses. Modern mining operations generate large amounts of waste, necessitating careful planning and well-informed decisions in terms of waste reduction, resource recovery and trash

Environmental management is governed in Zimbabwe under the Environmental Management Act (CAP 20:27) of 2002. According to the Environmental Management Agency (2015), one of the key factors contributing to declining environmental health conditions in Zimbabwe is improper solid waste management methods. Despite the fact

that the Act has several important measures, overall enforcement of the Act is still quite weak, as Maseva (2005), Tsiko and Togarepi (2012) have noted. Furthermore, the Act fails to explicitly state the waste management requirements that must be followed. It neglects crucial components of waste management, such as garbage sorting and separation at the point of generation. The policies in Zimbabwe that affect solid waste management do not emphasize the importance of waste segregation at the source to stakeholders in solid waste management systems. A study of the importance of integrated solid waste management in the Glenview Area 8, Harare, found that critical features such as trash segregation at sources are rarely practiced. Mixed solid wastes at illegal disposal sites and in some observed bins demonstrated this (Mangundu et al., 2007). Resource recovery, which involves the extraction of commercially viable material or energy from solid wastes, has not been established in poor nations, according to Dev (2007).

2. The Study Area

Unki Platinum Mine (Figure 1) is a 120,000-tonne-per-month enterprise located 60 kilometers east of Gweru on Zimbabwe's Great Dyke (Matthey, 2010). Unki Mine is a board-and-pillar underground mine with no tracks. Underground access is provided by a two-shaft decline shaft system, one for personnel and material transport and the other for ore transport. Both decline shafts are currently on a reef, with ore being transferred straight onto the main decline shaft conveyor by strike belts from eight mining sections. The newly built 120,000 tonne per month concentrator plant is treating run-of-mine ore ahead of schedule, having attained steady-state operation in the third quarter of 2011. The study area is located in agro-ecological region 3, which is a semi-intensive agricultural zone with annual rainfall ranging from 650 to 800 mm (Matsa and Muringaniza, 2010). Dry miombo forest (Brachystegiaspeciformis and Julbernardia) is the most common vegetation type. The Unki East mine is located in the Chironde Range on the Great Dyke, with the Umtembekwe River as one of the nearby rivers. Pakame Mission, about 40 kilometers north of Zvishavane and very close to Guruguru bornhardt, a volcanic solid granite hill in Shurugwi rural area, Tongogara High School, a government-operated boarding school 40 kilometers east of Tongogara, and Hanke Adventist High School, an SDA run school 10 kilometers north of Tongogara, are among the many schools in the Shurugwi area. Vungwi and Tumba are two of Shurugwi's excellent rural primary schools.

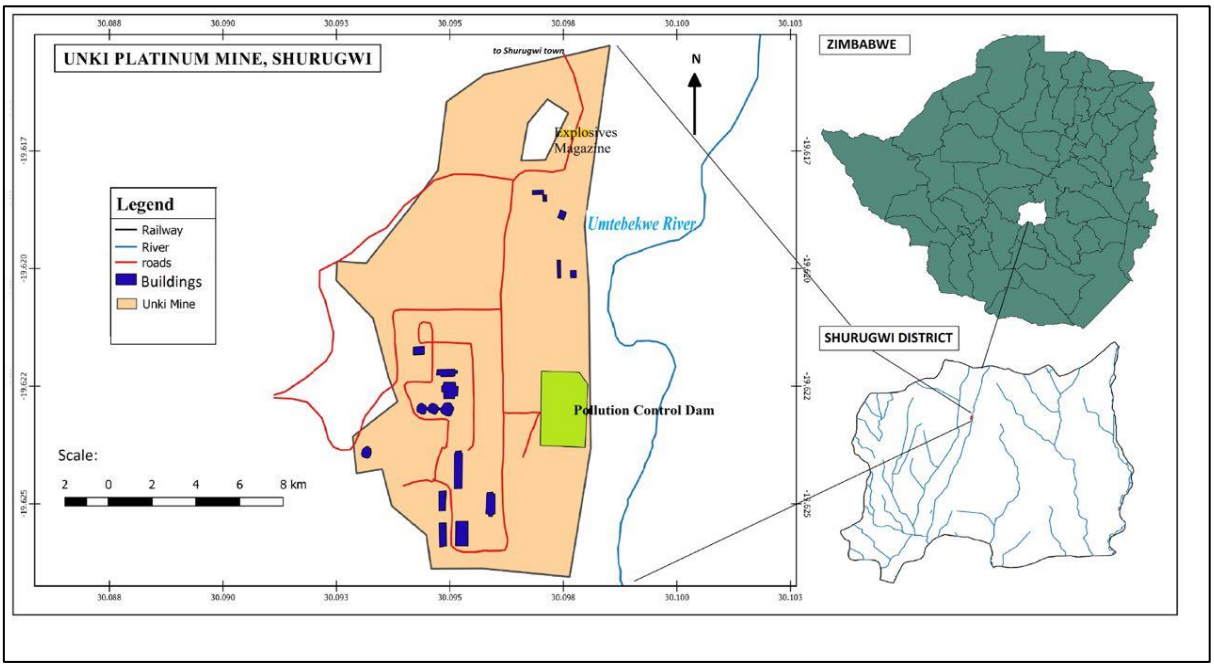


Figure 1: Study Area: Unki Platinum Mine, Shurugwi

3. Research Methodology

Several methods were employed in the collection, presentation and analysis of data. Initially, archival research was employed to obtain the national, regional and global situations on waste management strategies. This involved surfing the internet and visiting the library on a data collection mission. A pilot study was then conducted so as to familiarize the researcher with the area of study. This was followed by the identification of possible constraints to be encountered in the following study. Key informants were identified while the delimitation of the study area was also done. In the actual collection of information interviews and questionnaires were employed. The data collected from the field was then used to provide the views that are expressed in this study. Secondary data for this study came from specialized periodicals including the International Journals of Environment and Waste Management, as well as organizational records and the internet. Access to published material was also available through research databases. The information gathered from numerous documents, journals, magazines, and books provided a rich amount of information for analysis. Secondary data sources saved time as they filled important knowledge gaps for the researcher. The data acquired was interpreted using statistical and descriptive methodologies. Microsoft Excel, SPSS, and Microsoft Word were used to analyze the information. With the help of Microsoft Excel 2013, quantitative data were presented as tables, graphs, pie charts, photos, and statistical values. Interviews, questionnaires, and secondary data responses were compared. The data acquired during the observations was also presented in images by the researcher. It formed the basis of the views expressed in this paper.

4. Results and Discussion

4.1 Major Types of Solid Waste Streams Generated in Different Departments

a. The Human Resources (HR) department

The main solid waste generated in the Human Resources (HR) department included garbage from office cleaning chores. According to the poll, 34% of waste was from food stuffs. In terms of generation, both papers and plastics accounted for 33%. The HR department handles the bulk of the paperwork. All waste in the HR department has a larger rate of generation, according to the results of the questionnaire survey. The researcher and the safety officer performed an interview with her, and she revealed that the HR department produces a lot of paper and food waste. Food is an everyday fundamental product that nearly every employee consumes, so food waste is a serious issue. Plastic trash is most likely generated since most food products are packaged with plastic on a huge scale. According to Watch (2004), trash generated on a regular basis in offices can be categorized into two major groups and a third minor category. To begin with, trash is generated as a result of daily activities such as paper, envelopes, packing, printing, newspapers, magazines, pamphlets, cardboard, and writing tools. Second, wastes such as catering items, food and drink containers, and tissues are generated by people who work in offices on a daily basis. Unused equipment, furniture, and plastics make up a third, more modest category. According to some studies, workplaces contain over 80% abandoned stationery (Watch, 2004). Understanding the activities at a location aids in determining the specific processes that result in waste generation (Cagno et al, 1999). The researcher noted normal office activities that generate papers, plastics, and food waste during interview sessions. Filing and printing documents, and eating lunch at workplaces are examples of these activities. Food and drink cans made of aluminium and steel, plastic bags and bottles, cardboard, and printer cartridges were among the other items found. In comparison to other departments, the HR department creates clean recyclable garbage that is easier to segregate, according to the study. Office trash, on the other hand, is mixed up. Food and wet garbage are combined with clean waste papers. This is due to the fact that offices have only one waste receptacle. As a result, if suitable segregation measures are not followed, the disposal of recyclable office waste will continue to rise. According to the study, smaller bins that may be billeted in offices for the disposal of various main solid waste created should be provided, as well as frequently collected.

b. Major Solid Waste Generated in the Engineering Department

According to the survey results, the engineering department generates both hazardous and non-hazardous solid waste. In terms of generation, food waste, hydraulic hose fragments, and air and oil filters accounted for the highest and equal share (16%). Papers received 15% of the vote, followed by plastics with 12% and filthy wood with 9%. Vehicle maintenance, welding and flame cutting, office and workshop maintenance, and electricity all contribute to solid waste in the engineering department. According to the researcher and the environmental assistant's interview, the engineering department's

main activity is the repair of surface and subsurface vehicles, thus substantial solid waste is generated, such as polluted hydraulic hoses, rubber, air, and oil filters. She did, however, show that receptacles for this specific form of contaminated solid waste created during vehicle repair accumulated more quickly. She went on to say that trash receptacles, such as plastic bins, have a limited capacity to hold certain types of solid waste and, as a result, quickly fill up, resulting in spillage. Plate 1 depicts the accumulation of contaminated/hazardous solid waste in the engineering department, which is more than other solid waste generated in the department.

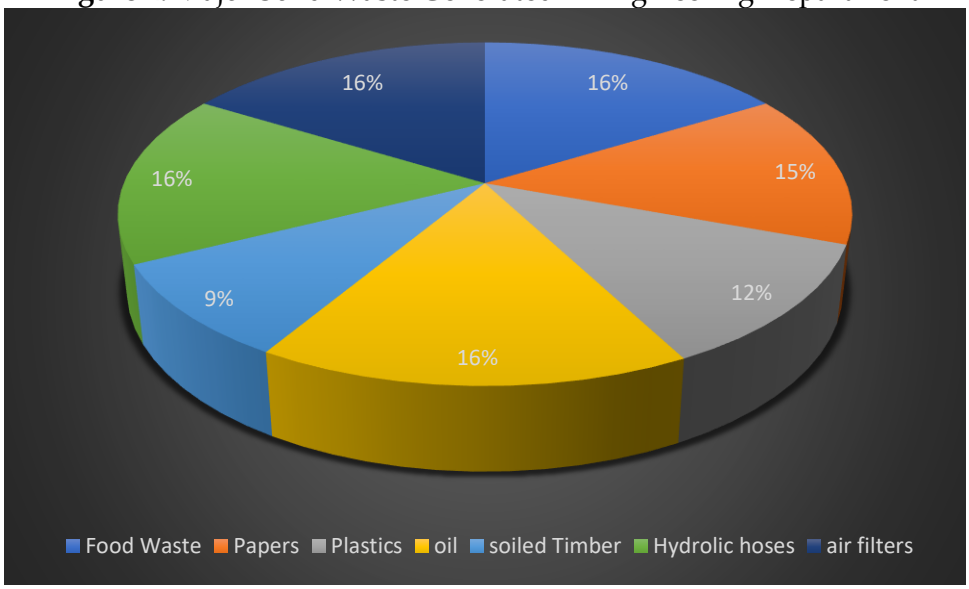
Plate 1: Hazardous Solid Waste Accumulation in the Engineering Department

Source: Field Research (2022).

This demonstrates that some receptacles are filled in a short period of time, causing overspill. As a result, employees will be more likely to use other, empty dumpsters. Employees are forced to dispose of solid trash in improper dumpsters as a result of this. Consequently, hazardous and non-hazardous wastes are mixed together. Receptacles are vital for successful recycling systems, according to Muchandiona (2013), because they allow for the separation and sorting of different forms of garbage. This demonstrates that the available receptacles are insufficient to handle the specific solid waste generated by the department. As a result, rather than being recycled, mixed garbage is disposed of in landfill. Aside from the issue of a lack of receptacles, the researcher claims that inefficient collection leads to trash accumulation. As a result, the

garbage collection schedule should be adjusted to avoid waste piling in the engineering department (Figure 2).

Figure 2: Major Solid Waste Generated in Engineering Department



Source: Field Research (2022).

c. Major Solid Waste in the SHEQ Department

The principal categories of solid waste created in this department included respirators, which accounted for 15 percent of total generation, followed by metallic gadgets at 11 percent, and rubber and lumber fragments at 7 percent for both. The mining department generates many distinct types of hazardous solid waste. This is due to the employment of explosives and initiators in mining operations to blow the hard, impermeable rocks underground. According to the survey, soiled/contaminated packaging (explosives cardboard boxes), chemical containers, and soiled paper and plastics are among the mining-contaminated solid waste. According to the researcher and the environmental assistant interview, the waste generated by the mining department comes from mine cycle operations such as supporting, drilling, blasting, and cleaning. Almost every activity produces hazardous waste. Kitula (2006) states that explosive cartridges are made up of harmful compounds such as nitrogen, ammonium, nitrate, carbon, coal powder, aluminium powder, and glycerin. The burning of these chemicals can be found in the waste created by these mining processes.

As a result, if these compounds are not properly disposed of, they are dangerous to humans, animals, crops, and the environment in general. During the discussion with the environmental coordinator, it was noted that the repercussions of discharging polluted solid waste into the ecosystem, whether intentionally or accidentally, are unfathomable. Some solid trash generated by the mining department, such as tainted explosives, cardboard boxes, rubber hoses, and soiled paper and plastics, is mixed and disposed in secret regions underground, according to the study. This suggests that the majority of underground workers are unaware of the importance of safe hazardous solid

waste disposal. If this material is discovered, it is collected and disposed of in a landfill, which may have negative environmental consequences.

d. Major Solid Waste in the Mining Department

Several types of waste were identified during the study including: Food Waste, Papers, Plastics, Old PPE and Respirators, Metallic, Contaminated Solid Waste, Rubber Hoses and Timber Pieces. In terms of trash generation, papers and food waste each accounted for 20% of the total. Old PPE and respirators accounted for 18% of the total, followed by plastics (16%), reagent bags (14%), and glasses and bottles (12%). Solid waste is generated in the MRM department through activities such as rock mineral sampling, which is then placed in reagent bags and dumped. Empty paint tins and spent paint brushes, according to the safety officer, are frequently the most hazardous solid waste generated in the MRM department. These are used to identify regions where rock samples will be taken. It was also noted that empty paint tins and used paint brushes are carefully managed because in order for an employee to be given a new paintbrush and paint tins, the old ones must be submitted for proper recycling and disposal techniques. Gainsville (2019) says that paint brushes and rags contaminated with hazardous waste (non-latex paints, cleaners, thinners, and strippers) and/or waste solvents cannot be thrown away and must instead be disposed of according to Environmental, Health, and Safety regulations. This means that by ensuring proper waste disposal at the mine, such practices reduce hazardous waste to the landfill. It can be concluded that the MRM department's handling of old paint tins and brushes is an important waste segregation approach that should be used in all departments for large specialized solid waste.

4.2 Overall Views of the Major Solid Waste Streams Generated at Unki Mine

The research identified the different forms of solid waste generated by each department. According to the findings, all of the departments listed papers, plastics, and food waste. Food waste accounted for 24 percent of the 6 departments surveyed, followed by papers at 23 percent and plastics at 18 percent. The majority of hazardous solid waste is found in departmental workshops rather than offices, according to the survey. Paperwork is completed in all departments, resulting in a higher trash generation rate. Also, every department generates plastic garbage, owing to the fact that most food products are packaged with plastic on a huge scale. According to the researcher and the environmental assistant interview, staff fails to segregate garbage at the source, despite the fact that practically all of the created solid waste has the potential to be recycled or reused in some form. Mixed solid trash is difficult to recycle, and community recycling groups often overlook it. As a result, such waste is sent to a landfill. The composition of solid wastes in some emerging countries, such as Thailand, the Philippines, and Malaysia, may comprise paper, plastic, packaging, and bulky wastes, with a rising trend toward waste generation. The main solid wastes generated by Thailand’s manufacturing industries were paper, cardboard boxes, plastic, and glass (Muttamara et al., 1994). According to Babu et al. (2009), industrial sectors lack source segregation of solid wastes with the purpose of on-site recycling as one of the waste minimization methods. This

demonstrates that most sectors produce a variety of recyclable solid waste, but lack the essential waste management practices. As a result, roadblocks to waste management measures like solid waste segregation at the source must be recognized and overcome. The overall percentage of significant solid waste generated at Unki Mine as a whole was calculated using responses from the questionnaire on the types of solid waste produced in each department.

4.3 Segregation of Solid Waste at the Source

In solid waste management, waste segregation at the source is critical because it facilitates material recycling and avoids contamination of trash that may otherwise be reused. Other unique solutions may be required for activities such as recycling, but the first step is to separate solid waste at the source (Ehrampoush, 2005). This demonstrates that waste source separation is an important first step in achieving efficient and long-term waste management. Separation of solid waste at the source was a question given to the respondents. According to the results of the poll, 52% of respondents segregate garbage at the source, while 48% do not. The garbage generated in offices is not segregated, according to 48% of respondents who said they do not follow source separation. All solid waste is collected and disposed of in a single container (metal bin). Food waste, PET bottles, plastics, papers, cans, and, in some situations, printer cartridges are mixed together. As a result, no waste separation initiatives were implemented at the office level. This reveals a discrepancy in solid waste separation practices. It is impossible to recycle plastics and papers that have been mixed with food waste. When asked about solid waste separation, however, the majority of respondents knew that waste had to be separated from other types of waste before being disposed of. This demonstrates the presence of solid waste segregation awareness efforts and education. Although awareness programs and training are conducted at the mine, the study found that motivational expectations for a future source separation program must be implemented. The majority of the participants, on the other hand, indicated that source separation is something they do.

4.4 Waste Collection Frequency per Week

The majority of respondents (36%) said waste is collected once a week, 29% said it is collected every day, 16% said it is collected twice a week, while 19% said rubbish is collected sporadically. However, during the interview with the environmental assistant, noted that one of the issues of solid waste segregation at the source is an insufficient collection. According to Chaudhary Singh and Gupta (2014), waste collection is difficult and expensive, and rubbish collection is normally done once or twice every seven days. According to the environmental assistant, one tractor is employed for garbage collection mine-wide, which in most cases results in the failure to comply with the waste collection schedule. Solid trash tends to gather faster and receptacles fill up quickly in particular departments where there are a lot of operations. Even though employees separate waste, some receptacles are filled in a short period of time, resulting in overspill, therefore employees are forced to use other bins that are not yet full. As a result, hazardous and non-hazardous trash are mixed together. The environmental assistant also mentioned

that hazardous and non-hazardous waste is collected by the same tractor. When non-hazardous garbage is contaminated, it has a negative environmental impact when disposed of in landfills. The current study's findings reveal that trash collection equipment at Unki Mine is inadequate. As a result, the researcher recommends that bin collection be re-evaluated in light of the concentration of solid waste-generating activities and volumes per section/department.

4.5 Employees' Knowledge of Waste Segregation

Toolbox discussions conducted every day at the start of work, according to 38% of the respondents, effectively educated them on the need for solid waste segregation at the source. In addition, 38% stated that they were not well-informed about trash separation. The majority of the awareness programs are held on the surface during the day, when subterranean personnel are not there, thus they miss out on such vital programs, according to the respondents. 24% of those polled said they had never been taught about the need for trash separation. However, during the interview with the safety officer, she stated that most new employees may not have been educated because most awareness campaigns are held quarterly throughout the year, making it difficult for them to keep up.

4.6 Benefits of Solid Waste Segregation at Source

The researcher used interviews and a questionnaire to gather information from respondents about the benefits of solid waste segregation at the source at Unki Mine for this study. During the discussion with the Environmental Coordinator, he said that keeping different forms of solid waste separated during generation, storage, and transportation allows for recovery. He also mentioned that contaminated or mixed waste streams are less valuable because they are more difficult to separate and thus more expensive. The separation of materials at the source results in a waste stream that is more homogeneous and of greater quality. As a result, recycling markets place a higher value on source-separated materials. Some respondents stated that separating garbage at the source encourages greater recycling and reusing, as well as lowering the risk of environmental destruction by separating dangerous elements. She stated during the interview with the researcher and the safety officer that trash segregation at the source saves time and money by eliminating the need to hire employees to sort waste. It enables for proper disposal of hazardous waste, which avoids contamination of the environment, according to some respondents. Recycling is made easier, resulting in a market for recycling companies and less pollution, particularly with plastics, if intercepted at the source. Rubbish sorting at the source has the potential to reduce the amount of waste entering landfills in developing nations by up to 50% by weight, while also promoting cost recovery schemes and extending the life of landfills (McDougall et al, 2001). Unki Mine must therefore provide all essential facilities, equipment, and programs to improve solid waste segregation at the source.

4.7 Barriers to the Segregation of Solid Waste at the Source

Some of the barriers to solid waste segregation at the source that respondents highlighted included the inability to recognize the color coding of bins for specific garbage, particularly those located underground, and hence throw rubbish into any container. Thirty percent of those polled said their bins were overflowing and they had to use other bins. When only one vehicle is used for waste collection, efficiency suffers, and the schedule is missed. The issue of worn-out bins was cited by 15 responders, while 26 others gave alternative explanations. Constraints for Failure to Segregate Solid Waste at Source (Source: Field Research, 2022). During the research interviews with the Environmental Coordinator, Environmental Assistant, and Safety Officer, they all stated that the failure of source separation is caused by the behavioural tendencies and negligence of most employees toward waste segregation systems. Employees may have the knowledge, but they lack the means to properly dispose of waste, according to several respondents. Because some departments, particularly offices, have just one receptacle, all garbage generated in offices is discarded in one receptacle. Employees tend to ignore and choose not to follow the rules because there is no penalty for breaking them. Other participants stated that there is a lack of adequate awareness and sufficient receptacles, particularly in underground working locations, as a result of which some solid waste is disposed in secret. Poor waste segregation occurs when the main garbage is not identified in parts. Some respondents stated that certain bins are perplexing, such as the unsorted bins, and that they are unsure what they are saving for. The primary impediments and challenges to implementing source separation of Municipal Solid Waste (MSW) in metropolitan settings, according to Towhid et al. (2018), include a lack of citizen accountability, a lack of understanding, and the expectation of receiving rewards.

In an interview with the environmental assistant, she stated that poor solid waste segregation at the source causes more recyclable garbage to be sent to the landfill, resulting in a failure to meet solid waste disposal targets. The respondents were given the opportunity to provide feedback on the best ways for achieving effective solid waste segregation at the source at Unki Mine through the questionnaires and interviews done by the researcher in this study. During the research interviews with the environmental coordinator, environmental assistant, and safety officer, they all agreed that incentive-based programs and green card awards should be implemented at the company to encourage employees to segregate waste at the source and to educate them on the importance of doing so. For departments to come up with viable and measurable targets to achieve solid waste segregation at the source for the designated waste streams, waste contests must be introduced. Employees can also come up with new ways to value and reuse waste through competitions. As a result, there will be no waste for the landfill. Some respondents suggested that, similar to how safety issues are handled at the mine, continuous training, periodic campaigns, and awareness for all new and existing personnel be conducted on waste management issues. More receptacles with simple signage indicating the different categories of solid trash must be provided. Inspections, as well as the release of waste statistics and the increased visibility of solid waste

segregation programs, are all necessary for successful and regular monitoring. These solutions would help to improve the source separation of solid waste.

4.8 Legislation on Waste Segregation at the Source in Zimbabwe

Environmental management in Zimbabwe is governed by the Environmental Management Act (CAP 20:27) of 2002. The Environmental Management Act (Cap 20.27), the Environmental Management (Effluent and Solid Waste Disposal) Regulations, and the Statutory Instrument 98 of 2010 (Plastic Bottles and Plastic Packaging) Regulations all oversee solid waste management. The same law governs mine waste disposal, including solid, liquid, and gas waste, and regulates how waste can be released into the environment. Unki Mine is authorised to dispose of municipal and office solid waste to the landfill in a quantity of 10 tonnes per month in compliance with Sections 69 to 71 of the Environmental Management Act (Chapter 20:27). In an interview with the environmental assistant, she stated that poor solid waste segregation at the source is causing more recyclable waste to be discarded to the landfill, resulting in the mine failing to meet solid waste disposal targets and, as a result, failing to comply with the Environmental Management Agency solid waste disposal standards. As a result, it is critical that Unki Mine provides all essential facilities, equipment, and procedures to enhance solid waste segregation at the source. Source segregation is a vital technique that must be executed successfully to optimize waste generated for sustainable waste management.

5. Conclusions

All the departments surveyed produced papers, plastics, and food waste, according to this study. Timber, metallic scraps, rubber, oil filters, contaminated garbage (soiled papers, rubber, and plastics), reagent bags, and glasses and bottles were among the other primary solid wastes created at the departmental level. The Unki Platinum Mine produces both hazardous and non-hazardous solid waste. The majority of hazardous solid waste was discovered in departmental workshops rather than offices, according to the data. As a result, the research disclosed that the majority of solid trash generated is recyclable, necessitating the separation of all solid waste. The main challenges encountered in solid waste segregation at the source at Unki Platinum Mine included lack of responsibility among employees (behavioral traits, lack of feeling in the need to separate the waste) and negligence of most employees to waste segregation systems; lack of effective awareness and enough receptacles, especially in underground working areas; failure to identify major waste in sections leading to poor waste segregation; and some bins being confused for example. Employees were demotivated by the mix-up of separated solid trash during collection, which resulted in spills and the use of other bins that were not intended for that garbage. Due to insufficient solid waste segregation, more recyclable material was dumped at the Unki Mine landfill, resulting in the failure to meet the target amount of solid waste delivered to disposal locations. Consequently, waste separation at the source proved ineffective at Unki Mine.

It is recommended that Unki Mine should hold competitions to encourage departments to develop long-term measures to achieve solid waste segregation at the source for the designated waste streams. Employees will be able to come up with novel ways of valuing and reusing garbage as a result of competitions, which would make segregation programs more effective. As a result, there would be less waste for the landfill. Environmental and safety officers at Unki Mine should undergo continuous training, periodic campaigns, and awareness for all new and old employees on waste management issues, similar to how safety issues are addressed at the mine. Daily safety discussions are held prior to the start of work and are the responsibility of everyone. Because waste is produced every day, waste issues should also be among the daily top-priority activities. As a result, every employee should be educated on solid waste segregation on a regular basis. Through regular effective monitoring and inspections, the Unki Mine environmental management department must assign responsibilities to line managers of separate departments to guarantee that adequate waste segregation processes are followed by their workers. Unki Mine should provide small color-coded receptacles that can be accommodated in offices to facilitate the segregation of different major solid waste produced in offices, and waste collection personnel should be given the right to refuse the removal of a waste bin containing the incorrect waste materials until the responsible department has rectified the situation. Unki Mine should deal with package suppliers in such a way that either the supplier returns the packaging or the mine reuses it, and it can hire an independent waste contractor on-site to sort garbage at the source. Assigning responsibility aids in the tracking of waste management systems and the identification of areas where there is a lack of compliance. If Unki Mine manages to implement these recommendations on its premises, it will be a model to other mines and organizations in Zimbabwe which will learn from her.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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