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Toward Zero Waste: Sustainable Practices in Waste Management at ETUT

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Abstract. The paper discusses Oguz Han Engineering and Technology University of Turkmenistan's (ETUT) waste management initiatives, particularly its Zero Waste Program aimed at minimizing waste generation and promoting sustainability across campus. Strategies include educational campaigns, eco-friendly purchasing, and collaboration with vendors for waste reduction, reuse, and recycling. ETUT employs structured waste categorization, centralized repositories for reusable items, and a recycling plant with advanced sorting machinery. Innovative methods like paper recycling and composting are used, along with exploring plastic repurposing into fibers and fuel. Organic waste management includes composting, notably reducing landfill waste. Inorganic waste reduction involves paper recycling, plastic conversion, and electronic repair and donation. The program emphasizes waste reduction through recycling and reuse, including upcycling workshops. Hazardous waste from laboratories is managed with local authorities for safe disposal, while relevant associations for environmental safety oversee sewage disposal. These strategies highlight ETUT's commitment to sustainability, positioning it as a regional leader in responsible waste management.

Keyword:
Waste pollution, waste management, reduce, reuse and recycle, organic waste, inorganic waste, biopolymers, sand-polymer plates

1. Introduction

Waste pollution has morphed from a localized nuisance into a global crisis. As human populations surge and consumption patterns evolve, our discards' sheer volume and composition threaten the well-being of our planet and ourselves. Understanding waste pollution's history, types, and impacts is crucial to formulating effective solutions. The concept of waste management is surprisingly recent. For most of human history, discarded materials were simply deposited nearby, leading to localized problems with sanitation and disease. The Industrial Revolution ushered in a new era of waste generation, with factories spewing out pollutants and cities struggling to manage growing waste streams. Early waste management solutions focused on collection and disposal in landfills, often with minimal environmental safeguards. The rise of synthetic materials like plastic in the mid-20th century further exacerbated the problem. Unlike organic materials that decompose naturally, plastic persists for centuries, accumulating in landfills and leaking into the environment. Our current "throwaway culture," fueled by planned obsolescence and fast fashion, has led to a dramatic increase in waste generation, particularly of short-lived, non-biodegradable items.

Today, we generate a staggering 2.12 billion tons of waste annually [7]. This equates to a line of garbage trucks circling the Earth 24 times. Landfills, once seen as a simple solution, are now reaching capacity and becoming environmental hazards. Leachate, a toxic cocktail of chemicals produced by decomposing waste, can contaminate soil and groundwater. Landfill gas emissions, primarily methane, a potent greenhouse gas, contribute to climate change.

Open burning of waste, another historical practice, releases harmful pollutants like dioxins and heavy metals into the air, affecting respiratory health and causing long-term environmental damage. Furthermore, the sheer volume of waste disrupts natural landscapes, with landfills encroaching on valuable ecosystems and wildlife habitats.

Plastic pollution deserves particular attention due to its ubiquity and persistence. Global plastic production has skyrocketed in recent decades, with only a meager 9% of the 400 million metric tons produced annually being recycled [8]. The rest ends up in landfills, incinerators, or worse – our environment. Plastic debris litters our oceans, forming vast garbage patches and disrupting marine ecosystems. Wildlife entanglement and ingestion of microplastics (fragments smaller than 5 millimeters) pose significant threats to countless species. Microplastics have even infiltrated the human food chain, raising concerns about potential health impacts.

Waste pollution's reach extends far beyond landfills and oceans. Electronic waste, or e-waste, is the fastest-growing waste stream globally. E-waste often contains hazardous materials like mercury, lead, and flame-retardants, posing health risks during improper disposal and recycling. Additionally, the rapid obsolescence of electronic devices contributes to a growing mountain of discarded technology. The healthcare sector also generates significant waste, including infectious materials, pharmaceuticals, and hazardous chemicals. Improper disposal of this waste can contaminate water sources and threaten human health. Construction and demolition waste, consisting of concrete, wood, and other debris, contributes to landfill overflow and requires careful management strategies.

The consequences of waste pollution are far-reaching and often hidden. Economically, the costs associated with waste management, healthcare related to environmental pollution, and lost ecosystem services are substantial. Socially, waste pollution disproportionately influences marginalized communities living near landfills and incinerators, exposing them to higher levels of environmental toxins. The aesthetic impact of waste pollution is also undeniable. Littered landscapes and polluted waterways detract from the beauty of our natural world and contribute to a general sense of environmental degradation. Perhaps most concerning is the long-term impact on human health. Exposure to environmental pollutants from waste disposal has been linked to various health problems, including respiratory illnesses, cancer, and developmental issues.

The good news is that we can address this crisis. Solutions require a multi-pronged approach involving individuals, corporations, and governments. Adopting a "reduce, reuse, recycle" philosophy is key at the individual level. This means buying less, choosing durable and reusable products, properly disposing of hazardous waste, and actively participating in recycling programs. Corporations must take responsibility for the waste footprint of their products. Investing in sustainable packaging, designing products for longevity and repairability, and implementing robust take-back and recycling programs are essential steps. Governments can play a vital role by enacting stricter regulations on waste disposal, promoting extended producer responsibility (where manufacturers are financially responsible for the end-of-life management of their products), and investing in innovative waste-to-energy technologies.

The paper delves into the waste management initiatives of the Oguz Han Engineering and Technology University of Turkmenistan (ETUT), with a specific focus on its Zero Waste Program designed to minimize waste generation and foster sustainable practices campus-wide. The program includes diverse strategies such as educational campaigns, eco-friendly purchasing, and collaboration with vendors to reduce, reuse, and recycle waste. ETUT has established structured waste categorization systems and centralized repositories for reusable office supplies, supported by a recycling plant equipped with advanced sorting machinery. Innovative waste treatment methods are utilized to address waste challenges, including recycling paper into new products and converting organic waste into compost. ETUT explores repurposing plastic waste into synthetic fibers and liquid fuel. Efforts to manage organic waste include food and yard composting, significantly reducing landfill waste. The university also promotes inorganic waste reduction through paper recycling, plastic conversion, and electronic device repair and donation. ETUT's Zero Waste program emphasizes waste reduction through efficient recycling and reuse practices, facilitated by activities like upcycling workshops. Hazardous waste from research laboratories is managed in collaboration with local authorities, ensuring safe disposal. Relevant associations to maintain environmental safety oversee sewage disposal. These comprehensive waste management strategies highlight ETUT's dedication to sustainability and environmental responsibility, positioning it as a regional leader in waste reduction and responsible waste management.

2. Unveiling the "Zero Waste" Movement at ETUT

In an era where environmental consciousness reigns supreme, the concept of "Zero waste" has blossomed into a global movement. As part of this growing initiative, ETUT is spearheading a transformative approach to waste management, aiming to not only lessen its environmental footprint but also set a shining example for the community and future generations.

2.1 The Road to Zero Waste

Zero waste transcends the traditional notion of waste disposal. It's a philosophy built on three pillars: minimizing waste generation at the source, maximizing recycling and composting opportunities, and ensuring any remaining waste is handled responsibly. This necessitates a complete overhaul in how we view, manage, and dispose of waste. It is a holistic strategy encompassing education, infrastructure development, policy changes, and fostering innovation – all with the ultimate goal of diverting waste from landfills and incinerators.

2.2 Cultivating a Sustainable Campus: ETUT's Commitment

By embracing sustainable waste management practices, ETUT envisions a campus environment where every action revolves around minimizing waste production, maximizing resource recovery, and promoting responsible consumption habits. This commitment permeates every facet of campus life, encompassing academic buildings, dormitories, dining halls, laboratories, and administrative offices. ETUT's unwavering commitment to sustainable waste management empowers it to act as a beacon of inspiration for other institutions and individuals.

More precisely, ETUT is dedicated to reducing its environmental impact by decreasing and treating organic waste on campus. The university has implemented several initiatives, including food waste composting and yard waste composting. These initiatives have diverted more than 10 tons of waste from landfills each year (*Table 1*).

Table 1. Total volume organic waste treated

Type of waste	**Amount (ton)**				
	total	**reduced**	**reused**	**down-cycled**	**up-cycled**
organic	24	4	5.5	7	
-food waste	13	2.5	3	5	
-tree cuttings, etc	8	1.5	2.5	2	
etc	3				

ETUT reduces its demands for fertilizers and fossil fuels by down-cycling organic waste. At the same time, these initiatives will enhance the influence of the university in a collective shift towards a zero-waste future.

2.3 Unveiling the Strategies

Educating the campus community about waste reduction and responsible consumption is paramount. This could involve workshops, seminars, and campaigns promoting reusable alternatives and proper waste segregation.

Upgrading infrastructure is crucial. This might include installing designated bins for recyclables and compostable, implementing composting facilities, and providing readily accessible water fountains to discourage single-use plastic bottles.

Implementing policies that incentivize waste reduction and responsible behavior can be a game-changer. This could involve introducing reusable container programs in dining halls, phasing out single-use plastics, and offering rewards for responsible waste disposal.

Fostering a culture of innovation can lead to groundbreaking solutions. Encouraging student participation in waste reduction projects, exploring novel waste-to-resource technologies, and collaborating with external partners can pave the way for a more sustainable future.

2.4 Dissecting Zero Waste

ETUT's commitment to zero waste paves the way for a greener future. However, achieving this ambitious goal requires a collective effort. By actively participating in waste reduction initiatives, embracing reusable alternatives, and advocating for sustainable practices, the entire campus community can become agents of change.

ETUT's approach to waste management presents a novel approach compared to other institutions through the country. One of the key innovations lies in the development and implementation of engineering devices for waste segregation, fragmentation and other. These devices, likely designed and produced using local materials and technology, represent a unique aspect of ETUT's waste management strategy. By creating custom-built equipment, the university can tailor solutions to its specific waste challenges and potentially reduce costs associated with purchasing off-the-shelf technology [6].

In addition, lecturers and students of university participates to international project competitions and workshops with their projects related "Zero Waste" program. Further, they are advocate and collaborate with foreign fellow professors, students for exchange experiences to refine and fill the gaps of this program. Further, these initiatives are encouraging contribution of the program in regional and global context [1].

Currently, Oguz Han Engineering and Technology University of Turkmenistan collaborates with the Academy of Sciences of Turkmenistan, the Ashgabat Glass Factory, and the Ovadandepe metal plant to run "Zero waste" program. Such partnerships can be instrumental in sharing knowledge, resources, and best practices, ultimately accelerating the progress of Zero Waste initiatives in Turkmenistan.

3. Automated waste sorting machine

With the increasing global focus on sustainability and environmental consciousness, the development of innovative solutions for waste management has become imperative. One such groundbreaking innovation is the automated waste sorting machine, a technological marvel that has the potential to revolutionize the way we handle and process waste [6].

3.1 Background and Significance

Traditional waste sorting processes are labor-intensive, time-consuming, and often prone to errors. Manual sorting not only requires significant human resources but also poses health and safety risks for workers. In contrast, automated waste sorting machines leverage cutting-edge technology to streamline the sorting process, enhancing efficiency, accuracy, and safety.

3.2 Functionality and Operation

Automated waste sorting machines utilize a combination of technologies such as computer vision, artificial intelligence, and automation systems to identify and segregate different types of waste. These machines can categorize items based on their material composition, shape, size, and color, enabling precise sorting of recyclables, organic waste, and non-recyclable materials. The machines are equipped with sensors and robotic arms that facilitate the separation of waste into designated compartments (*Figure 1*).

One of the primary advantages of automated waste sorting machines is their ability to process large volumes of waste rapidly. By automating the sorting process, these machines significantly reduce the time and labor required for waste management tasks. Moreover, they enhance the efficiency of recycling operations by ensuring that materials are sorted correctly, leading to higher recycling rates and improved resource recovery.

3.3 Environmental Impact and Sustainability

The implementation of automated waste sorting machines has far-reaching environmental implications. By promoting the proper segregation of waste streams, these machines facilitate increased recycling and reduce the amount of waste destined for landfills. This not only helps conserve natural resources but also minimizes the environmental footprint of waste disposal. Additionally, automated sorting contributes to the circular economy by promoting the reuse and recycling of materials, fostering a more sustainable approach to waste management.

Figure 1. Automated waste sorting machine

3.4 Challenges and Future Prospects

While automated waste sorting machines offer significant benefits, their adoption may face challenges related to initial investment costs, technical complexity, and maintenance requirements. However, advancements in technology and growing awareness of the importance of sustainable waste management are driving the continued development and deployment of these innovative solutions. Prospects include the integration of smart features such as real-time monitoring, data analytics, and remote-control capabilities to further, enhance the efficiency and effectiveness of waste sorting processes.

3.5 Results

Consequently, automated waste sorting machines represent a transformative solution for modern waste management practices. By combining advanced technology with environmental stewardship, these machines hold the key to optimizing waste processing, promoting recycling, and advancing sustainability goals on a global scale. With further innovation and strategic implementation, automated waste sorting machines are poised to play a significant role in shaping a greener and more resource-efficient future.

4. Starch-Based Biopolymers

4.1 Background

Biopolymers are materials that offer a sustainable alternative to conventional plastics. Derived from renewable resources like plant starches, cellulose, and even bacteria, biopolymers boast a range of properties that make them game-changers. One of the most compelling features of biopolymers is their inherent sustainability. Unlike traditional plastics, biopolymers are derived from renewable resources that can be replenished through responsible agricultural practices. This reduces our dependence on finite fossil fuels and helps mitigate the environmental impact associated with their extraction and processing.

The biodegradability of biopolymers is another key advantage. Many biopolymers can be broken down naturally by microorganisms under the right conditions, unlike traditional plastics that can persist in the environment for centuries. This translates to a significant reduction in plastic pollution, a pressing environmental issue with detrimental effects on wildlife ecosystems and human health. Biopolymers also offer a surprising degree of versatility. Depending on the source material and processing techniques, biopolymers can be tailored to possess a wide range of properties. Some biopolymers are strong and durable, making them suitable for applications like packaging and construction materials. Others are more flexible and lightweight, ideal for use in textiles, films, and even medical devices.

The biocompatibility of certain biopolymers opens doors for exciting advancements in the medical field. These materials can be designed to be non-toxic and compatible with human tissue, making them ideal for applications like drug delivery systems, implants, and wound dressings. This biocompatibility reduces the risk of rejection by the body, paving the way for innovative medical treatments. The development of biopolymers is still a burgeoning field, but the potential is undeniable. As research and development continue, we expect to see biopolymers with more advanced properties and functionalities. This shift towards bio-based materials presents a significant opportunity to create a more sustainable future, one where our everyday needs are met without compromising the health of our planet [4].

By embracing biopolymers, we can move towards a world less reliant on fossil fuels, minimize plastic pollution, and unlock innovative solutions in various industries. The future of biopolymers is bright, and their potential to revolutionize the way we live and interact with the environment is truly exciting.

4.2 Materials and Method

The study employed cornstarch, acetic acid, glycerol, soil, and distilled water as key ingredients. The required equipment included analytical scales, a blender, a hot plate, a 150-mesh sieve, an oven, a small main testing machine, a measuring cup, a beaker, a frame, a mortar and pestle, and a thermometer.

Firstly, the corn is cleaned to remove dust, gravel, sand, or cob pieces. It is then soaked in porcelain or stainless-steel tanks at a temperature between 50-55°C for about 35-40 hours to prevent alcohol formation due to fermentation. Subsequently, the husk is removed after the corn softens.

The soaked corn is dried and ground into flour. The resultant corn flour is then soaked to remove the protein, separated from the starch grains, and washed with water. The extracted sediment, in the form of wet starch lumps, is then dried to approximately 15% moisture content.

Following this, the starch is milled to 3 times with a tool containing a sieving mesh of 150. To initiate the production, 4 grams of corn starch and 12 ml of glycerol are weighed, alongside varied quantities of acetic acid. The best acetic acid concentration, as determined from previous tests, is selected. The acetic acid solution is then added to a beaker containing the cornstarch solution and heated using a hot plate at 80°C for 35 minutes [4].

Subsequently, glycerol is integrated into the cornstarch mixture according to the prescribed composition, followed by further heating on a hot plate at 85°C for 20 minutes. The resulting mixture is poured into the frame and heated in an oven set to 55°C for 7 hours 30 minutes. The final plastic sample is then removed from the frame. As a result, cornstarch bioplastic was obtained [4] (*Figure 2*).

4.3 Result

Throughout the study, careful execution and precise measurements led to the successful attainment of the bioplastic material. Overall, this study presents a promising method for bioplastic production using cornstarch, paving the way for more sustainable plastic alternatives [4].

Figure 2. Starch-based biopolymers

5. Producing technical salt from the waste of Garlyk potassium mining and processing plant

5.1 Background

In Turkmenistan, significant emphasis is placed on securing ecological welfare, conserving the native environment, and the effective utilization of natural resources. Caring for the environment and addressing important challenges in this area are closely related to the well-being of current and future generations. Therefore, establishing waste-free industries in Turkmenistan, as well as waste processing, is considered one of the main areas in ensuring environmental safety. According to the "State Program for Integrated Development of Chemical Science and Technology in Turkmenistan for 2021 - 2025", the products of chemical science and new chemical technologies in the country are ecologically clean, energy-saving, substitute goods imported from abroad, and competitive in the world market.

As is known, inorganic salts do not have equal importance for the economy. Among mineral fertilizers, potassium salt occupies an important place. One of the main plants for the production of potassium fertilizers in Turkmenistan is the Garlyk mining and processing plant for the production of potassium fertilizers. This large complex is the first industrial enterprise in Turkmenistan for the production of potassium fertilizers, as well as one of the largest mining and processing enterprises in Central Asia. Potassium chloride is one of the main products of the Garlyk potassium mining and processing plant. This production enterprise not only meets the needs of Turkmenistan’s agriculture for high-quality potash fertilizers but also allows it to annually, export more than a million tons of valuable products. For the production of chlorinated lime, sylvinite ore serves as a raw material, which is mined by the mining method. The annual capacity of the underground complex of the enterprise is 7.8 million tons of sylvinite ore. The main mineral composition of the ore is sylvinite, halite, water-insoluble, and slightly soluble minerals. The mined raw materials are processed and enriched in the beneficiation unit. After passing the technological systems, ready potassium fertilizers are accumulated in the storage of the complex [2].

A large amount of waste remains during the production process in the Garlyk potassium mining and processing plant. In the flotation method of beneficiation of sylvinite ore, the main production wastes are halite waste and halite clay-salt sludge. The remaining waste is stored above ground near the plant in a specially designed salt collection facility.

The amount of waste here increases every year. As a result, the region will face environmental problems in the future such as pollution of air, soil, surface, and groundwater, reduction of biological diversity, and imbalance of ecological systems. Therefore, scientific research and experimental works are being conducted at ETUT on the processing of halite waste and obtaining new products from it. Halite waste processing is very important not only in Turkmenistan but also in the region to ensure ecological security [2].

5.2 Materials and Method

Based on the experiments, the technology of extracting sodium chloride (technical salt) from halite waste was developed. The technology is a low step, where no additional reagents are used. For the production process, waste from Garlyk potassium mining and processing plant, distilled water and muffle furnace are used. As we mentioned above, the residue of the Garlyk potassium mining and processing plant is the residue from the potash fertilizer production of that complex. It contains a large amount of sodium chloride [2].

Wastes from the Garlyk potassium mining and processing plant are weighed on an analytical balance and dissolved in distilled water in a magnetic stirrer at a temperature of 100^0 C for 30 minutes. The solution is then filtered 4 times. The filtered melt was heated in a muffle the furnace at 150^0 C for 2 hours. After heating in a muffle furnace, water is evaporated to obtain 98.29% technical salt. The amount of technical salt obtained exceeds 80% of the residual waste [2] (*Figure 3*).

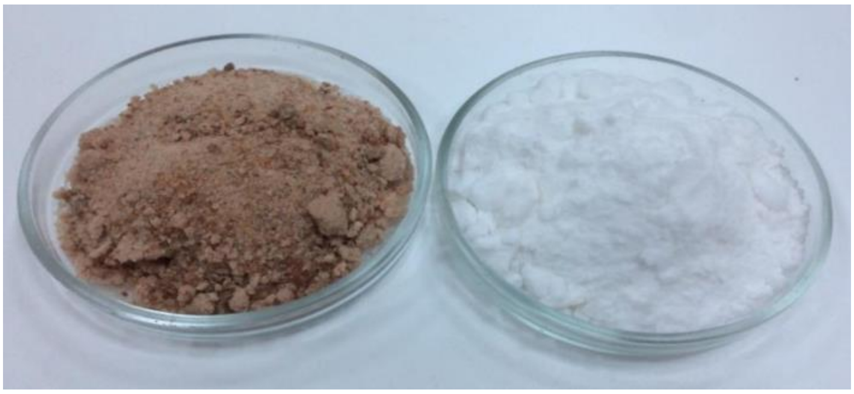

Figure 3. Garlyk plant waste and technical salt

5.3 Result

The obtained technical salt can be used in various sectors of the economy: in paint production, baking soda production, chlorine-alkali production, paper production, melting of snow on roads in winter, and agriculture [2]. In addition, recycling Garlyk plant waste is reduces need for new raw materials, thereby conserving natural resources. The extraction process developed does not require additional reagents, which minimizes the use of additional chemical resources and reduces potential environmental impact. The process results in a high yield of technical salt (98.29%), which signifies efficient utilization of the waste material.

6. Liquid organic fertilizer from licorice root waste

6.1. Background

Organic waste, stemming from the remains of living organisms, plays a pivotal role in the global waste stream. This biodegradable waste encompasses a wide array of materials, including food scraps, yard trimmings, paper, and wood. The management of organic waste is of paramount importance, given its substantial contribution to global waste generation and its potential environmental impact.

Sustainable management practices, such as composting and anaerobic digestion, are essential in curbing the negative repercussions of organic waste accumulation. The effective handling of organic waste not only mitigates environmental hazards but also offers opportunities for resource recovery, presenting a sustainable approach to waste management.

The following sections will delve into the technology for preparing fertilizer from organic waste, including its composition, challenges in managing it, and environmental implications that hold promise for addressing this critical issue. A thorough comprehension of organic waste and its management can lead to the development of well-informed strategies that advocate for environmental preservation and the sustainable utilization of resources [3].

6.2 Materials and Method

The study is carried out at the "Ecological Biotechnology" research center of ETUT. The paper aims to prepare liquid fertilizer from Licorice root residues and utilize it in fields belongs ETUT.

Global advancements in the preparation of liquid organic fertilizers have been investigated. Licorice root residues of the "Buyan" agro-complex named after S.A.Nyyazov in Turkmenabad were used for the study (*Figure 4*). A dry and dark-colored liquid extract is obtained by re-cultivating the root in the complex. The special group collects an average dry weight of 7,000 tons of root annually. On average, about 3 thousand tons of cut and crushed betel root are prepared, and 1300 tons of thick and dry extract of the root are obtained from it. Organic waste from the production process is stored on land. Because of the processing of the generated organic waste, it will be possible to obtain valuable liquid organic fertilizer (compost), which is necessary for crops. Additionally, the recycling of Licorice root residues of the agro-complex contributes ecological well-being of the city [3].

Figure 4. Waste of "Buyan" agro-industrial complex of Turkmenabad

Based on the experiments, the composition of the preparation of bio-compost from the waste of the root was developed. To prepare liquid compost, 500 ml of 1% sodium hydroxide ($NaOH$) solution (1:10 ratio) was added to 50 g of sludge, heated at 150 °C for 3 hours and 200 ml (used sodium hydroxide) was added to the resulting solution. (40% of a 1% solution of $NaOH$) is added to distilled water. Then the solution is heated at a temperature of 200 °C until the density of the solution reaches 1.12 g/l. As a result, liquid organic fertilizer (compost) is obtained [3] (*Figure 5*).

Figure 5. Liquid organic fertilizer

6.3 Results

The technologies used in the world for the preparation of liquid organic fertilizer have been studied, and a composition for the preparation of liquid organic fertilizer from local industrial waste has been developed. Liquid organic fertilizer contains 8-10% humic substances. The proposed technology is economically viable. In addition, converting licorice root waste into a valuable product contributes to waste reduction and diversion from landfills, potentially reducing methane emissions. Further, it will save direct usage of the shoot of licorice plant. Furthermore, liquid organic fertilizer can be widely used to increase the productivity of agricultural fields and the growth of crops [3]. Moreover, the process of creating liquid organic fertilizer from licorice root waste at ETUT involves specific steps and conditions that can be adapted to other types of organic waste and different environments. While licorice root waste is specific to ETUT, other regions can use their own local organic waste materials, such as food scraps, agricultural residues, or yard trimmings. The equipment and technology (e.g., heating systems, $NaOH$ solution preparation) used at ETUT should be available or adaptable in the new environment. Meanwhile, the local climate, availability of space, and environmental regulations must be taken into account.

7. Inorganic Waste Treatment

7.1 Recycling Paper Waste for Circular Economy

The university's donation of approximately 5 tons of paper waste to a recycling company is a testament to its commitment to promoting a circular economy, a sustainable system aimed at minimizing waste and maximizing resource efficiency. This initiative illustrates the university's proactive stance towards responsible waste management and environmental stewardship. By recycling paper waste into new paper products, the university significantly reduces the volume of waste destined for landfills, thereby mitigating environmental impact and minimizing the strain on landfill capacities. Additionally, the conversion of paper waste into new paper products contributes to the conservation of natural resources, including water and wood, which are vital components of traditional paper production. Through this process, the university plays a basic role in lowering the environmental footprint associated with paper manufacturing while conserving valuable resources.

Moreover, the university's engagement in paper recycling aligns with the principles of sustainable resource management, inspiring environmentally conscious practices within its campus community. By promoting the circular economy through paper recycling, the university sets an example for responsible waste management practices, emphasizing the significance of waste diversion, resource conservation, and environmental responsibility.

Overall, the university's initiative to recycle paper waste signifies a holistic approach to sustainability, emphasizing the prudent management of resources, waste reduction, and environmental preservation within the campus and beyond.

7.2 Converting Plastic Waste into Sand-Polymer Plates

7.2.1 Foreword

Nowadays the high demand for polymer products worldwide causes the production of polymer products at a higher level. Mass production of these products leads to an increase for waste. The biodegradation of polymer products continues for a million years. Therefore, developing new, environmentally friendly materials and products using polymer waste is important for ensuring the environment's well-being.

Scientific research aims to study the physicochemical properties of polymer products, obtain economically and environmentally friendly products from their waste, and prepare important suggestions for the national economy [5].

The physicochemical properties of polymer products make it possible to obtain economical and environmentally friendly sand-polymer products from their waste. Sand-polymer products are a mixture of solid polymer waste and sand. Sand polymer products are permanent and chemically stable compared to conventional concrete plates. Because the polymers within sand polymer products give them strength, flexibility, durability, and high aesthetic properties. Sand polymer products can be used in the construction industry for the production of roofing material (tiles), plates, well materials, as well cover used in the regulation and management of sewage networks. In consequence, establishing the production of sand polymer products in Turkmenistan will provide a great opportunity to ensure environmental well-being [5].

7.2.2 Materials and Method

Sand fractions less than 3 mm, single or secondary processing, crushed polymers (plastics), inorganic dyes and stabilizers are necessary for the production of sand-polymer plates. Chromium can be used to make sand-polymer plates green, titanium white, and iron oxides to coral, orange, or brown. For the manufacture of sand-polymer plates, the sand is first cleaned, then mixed with crushed polymers, and processed on special equipment. To perform a press, an extruder, and a concrete mixer are also used in this process. After heating and compression of this material, its moisture resistance increases, and friction decreases [2]. The research was carried out at three different concentrations in the Ecological Biotechnology Research Center of the Oguz Han Engineering and the Technology University of Turkmenistan according to the methodology was obtained sand polymer plates (*Figure 6*).

Figure 6. Sand-polymer plates [9]

The weight of sand polymer plates depends on their dimensions, composition, and manufacturing technology. Based on experiments, the weight of sand-polymer plates is 0.9-0.95 kg. Their thickness was 60-65 mm [5].

7.2.3 Results

Based on the experiments, the obtained products were tested for resistance to compression and water permeability. According to the results of the experiments, it was found that the best results were obtained by sand-polymer plates obtained from a 1:3 mixture of polyethylene and crushed particles of plastic waste and sand. Throughout the study, the following results were obtained:

- Sand-polymer plates are competitive in the world market and are considered a demanded building product with high economic benefits and low material costs;
- The importance of using polymer waste as a filler not only with sand but also with other building materials has been studied;
- Based on the conducted research, it was found that sand-polymer plates produced without cement and water with a ratio of 1:3, are comfortable and durable, meet all requirements, and are an environmentally friendly, cost-effective product;
- Sand-polymer plates can be installed on bases consisting of sand, sand-gravel mortar, and concrete;
- Sand-polymer products can be used to manufacture manhole covers, drainage pipes, and other components of waste management systems. Their strength and durability ensure the longevity and reliability of these critical infrastructures;
- The chemical resistance of sand-polymer products makes them ideal for use in sewage systems, where they can withstand exposure to harsh chemicals and reduce the risk of leaks and contamination;
- Sand-polymer roof tiles offer excellent weather resistance, insulation properties, and aesthetic appeal. They provide a durable and low-maintenance roofing solution;
- Incorporating recycled materials, sand-polymer roofing products contribute to sustainable building practices and reduce the environmental impact of construction activities.

7.3 Repair and Reuse of Electronic Devices

The university's initiative to collect electronic devices for repair at an on-campus shop embodies a sustainable approach that prioritizes extending the lifespan of electronic devices and reducing electronic waste generation. By promoting repair and reuse as alternatives to disposal, the university actively contributes to a culture of sustainability and resource conservation. This initiative not only displays the university's commitment to environmental responsibility but also empowers the campus community to adopt responsible consumption patterns. By encouraging individuals to repair and reuse electronic devices instead of discarding them, the university fosters a mindset of mindful consumption and waste reduction.

Figure 7. An on-campus electronics repair shop

Further, the repair and reuse of electronic devices align with the principles of the circular economy, where products are kept in use for as long as possible to maximize their utility and minimize environmental impact. By engaging in this practice, the university sets an example for sustainable waste management practices and emphasizes the importance of responsible stewardship of resources within its campus community (*Figure 7*).

Furthermore, the repair and reuse of electronic devices initiative at the university serves as a tangible demonstration of its dedication to minimizing electronic waste, promoting a circular economy, and instilling a culture of sustainability among students, faculty, and staff.

7.4 Donation of Glass Products and Recycling Metallic Trash

The ETUT's approach to waste management goes beyond simply throwing things away. Their dedication to waste diversion and landfill reduction is evident in their practices of donating glass products to the Ashgabat Glass Factory and transferring metallic trash to the Ovadandepe metal plant for recycling. By donating glass and recycling metal, the university participates in the circular economy. In a traditional linear economy, resources are extracted, used, and then discarded, creating waste that ends up in landfills. The circular economy disrupts this cycle by focusing on reusing and repurposing materials. Donated glass can be melted down and remanufactured into new products, while scrap metal can be refined and used to create entirely new items. This continuous loop minimizes the need for virgin resources and reduces the environmental impact associated with their extraction and processing.

In addition, it has an environmental benefit. Because waste management practices offer a multitude of environmental advantages. Landfill diversion is a key benefit. Landfills take up valuable land, pollute the surrounding environment with methane gas, and can leach harmful chemicals into the soil and water. By diverting waste from landfills, the university helps to conserve space, reduce greenhouse gas emissions, and protect the environment.

Recycling glass and metal conserves valuable natural resources. Manufacturing new glass and metal products requires significant energy and raw materials. By reusing existing materials, the university reduces the demand for virgin resources and the associated environmental impact of their extraction. This not only benefits the environment today but also ensures the availability of these resources for future generations.

These practices serve as a model for sustainable waste management. Recycling and donating waste for reuse demonstrate a commitment to responsible resource use and environmental stewardship. This approach can inspire others, including businesses and individuals, to adopt similar practices, leading to a larger positive impact on the environment.

7.5 Result

The methods for recycling paper waste, converting plastic waste into sand-polymer plates, and repairing and reusing electronic devices at ETUT also hold potential for replication. Adequate facilities for recycling paper, processing plastic waste, and repairing electronics are necessary. Besides, these facilities must meet local standards and regulations. The technology used (e.g., equipment for making sand-polymer plates) must be compatible with local waste types and available resources.

Moreover, ETUT is committed to minimizing its environmental footprint by reducing and managing inorganic waste on campus. Table 2 illustrates the tangible effects of the "Zero Waste" program on the amount of waste produced on the ETUT campus.

Table 2. Total volume inorganic waste treated

Type of waste	Amount (ton)				
	total	reduced	reused	down-cycled	up-cycled
inorganic non-toxic	46	7	7	9	3
-paper	9	2	2	2	1
-soft plastic	18	3	2	5	2
-hard plastic	15	2	3	2	
Etc	4				

Finally, the university's comprehensive waste management initiatives underscore its proactive stance towards sustainability, resource conservation, and environmental protection. By implementing a diverse range of strategies aimed at reducing waste generation, promoting recycling, and fostering a circular economy, the university sets a precedent for responsible waste management practices within the education sector. These initiatives not only align with the university's sustainability goals but also inspire the campus community to embrace environmentally conscious behaviors and contribute to a greener, more sustainable future.

8. Conclusion

ETUT's zero waste program exemplifies the transformative power of institutional commitment, driving a global shift towards sustainability where responsible resource management becomes standard practice, rendering waste a relic of the past. The integration of automated waste sorting machines stands as a cornerstone in modern waste management, combining technology with environmental consciousness to streamline waste processing, boost recycling efforts, and propel global sustainability endeavors. This innovative approach heralds a greener, more efficient future with far-reaching impacts.

Further, the success in producing bioplastic material using cornstarch highlights a promising avenue toward sustainable plastic alternatives. The derived technical salt offers versatile applications across various sectors underscoring the economic potential and sustainability benefits. Additionally, the study's findings on sand-polymer plates reveal their competitiveness in the global market, their flexibility as a sought-after building product, and their capacity to meet requirements while offering environmental and cost advantages. These plates, with their diverse applications and aesthetic appeal, have the potential to revolutionize eco-friendly construction practices, further solidifying the university's commitment to sustainability and environmental stewardship. By highlighting the recycling of paper and metal, as well as the donation of glass products, the study promotes the concept of a circular economy. This encourages a shift from linear to circular systems, where waste becomes a resource.

ETUT has applied suitable research methods to study different types of waste, but it requires further research to manage remaining waste effectively, similar to other organizations.

Overall, carefully considering factors such as economic feasibility, infrastructure limitations, policy alignment and addressing potential challenges, the results of ETUT's study can be effectively applied on a larger scale, contributing to a more sustainable future.

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