MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF ENVIRONMENTAL SAFETY, ENGINEERING
AND TECHNOLOGIES
DEPARTMENT OF ECOLOGY

APPROVED TO DEFENCE
Head of the Graduate Department
_________________ V.F. Frolov
«_____»________________ 2020

MASTER THESIS

(EXPLANATORY NOTE)

SPECIALTY 101 «ECOLOGY»
Training Professional Program "ECOLOGY AND ENVIRONMENTAL PROTECTION"

Theme: «Organization of SDW recycling in the construction industry»

Done by:
student of the EC-202m group, Rostuslav Biletskiy
(student, group, surname, name, patronymic)

Scientific Supervisor:
Ph.D., Associate Professor of the Ecology Department, Lesia I. Pavliukh
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KYIV 2020

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ ЕКОЛОГІЧНОЇ БЕЗПЕКИ,
ІНЖЕНЕРІЇ ТА ТЕХНОЛОГІЙ
КАФЕДРА ЕКОЛОГІЇ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
_____________ В.Ф. Фролов
«_____» ____________ 2019 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ МАГІСТРА

ЗА СПЕЦІАЛЬНІСТЮ 101 «ЕКОЛОГІЯ»
ОПП ««ЕКОЛОГІЯ ТА ОХОРОНА НАВКОЛИШНЬОГО СЕРЕДОВИЩА»

Тема: «Організація повторного використання ТПВ у будівельній галузі»

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(підпис) (П.І.Б.)

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КИЇВ 2020

NATIONAL AVIATION UNIVERSITY

Faculty of Environmental Safety, Engineering, and Technologies

Department of Ecology

Direction (speciality, major): specialty 101 “Ecology”, TPP “Ecology and Environmental Protection”

(code, name)

APPROVED
Head of the Department
___________ Frolov V.F.
«____» _________ 2020

MASTER THESIS ASSIGNMENT

Rostuslav V. Biletskiy

1. Theme: «Organization of SDW recycling in the construction industry» approved by the Rector on October 11, 2019, № 2364/ст.

2. Duration of work: from 14.10.2019 to 09.02.2020

3. Output work (project): waste accumulation data.

4. Content of explanatory note: (list of issues): to analyse the waste accumulation issues in the World and in Ukraine, to investigate the existing waste recycling methods, to propose a alternative technology of MSW recycling in constructionidustry, to make practical recommendations for the application of the proposed technology.

5. The list of mandatory graphic (illustrated materials): tables, figures.

6. Schedule of thesis fulfillment

№ з/п	Task	Term	Advisor's signature
1	Receiving of topic assignment, search of the literature and methodology development	18.10.2019 – 20.10.2019	
2	Preparation of the main part (Chapter I)	21.10.2019 – 10.11.2019	
3	Preparation of the main part (Chapter II)	10.11.2019 – 17.11.2019	
4	Preparation of the main part (Chapter III) and drafting explanatory note for the first preliminart presentation	17.11.2019 – 15.12.2019	
5	First preliminary presentation of the diploma work	16.12.2019	
6	Preparation of the main part (Chapter IV)	16.12.2019 – 28.12.2019	
7	Making conclusion	02.01.2020 – 09.01.2020	
8	Drafting explanatory note for the second preliminart presentation	10.01.2020 – 22.01.2020	
9	Second preliminary presentation of the diploma work	23.01.2020	
10	Formulation of the conclusions and recommendations of the diploma work, editing, consultation with standard's incpector, remarks and recommendations consideration	23.01.2020 – 26.01.2020	
11	Finalizing, signatures receiving, plagiarism verification, preparation to the final protection (presentation)	27.01.2020 – 04.02.2020	
12	Protection (presentation) of the final version of the diploma work at the department	05.02.2020	

7. Consultant(s) of certain chapter(s):

Chapter	Consultant (academic rank, S.N.P)	Date, signature	
		Given by	Accepted by
Labor Precaution	Viktoria V. Kovalenko, Ph.D., Assoc. Prof. of the Civil and Engineering Safety Department		

8. Date of task issue: «____» __________ 20__

Diploma (project) advisor: ________________ (advisor's signature) Lesia I. Pavliukh (S.N.P.)

Task is taken to perform: ________________ (graduate's signature) Rostuslav V. Biletskiy (S.N.P.)

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет екологічної безпеки, інженерії та технологій

Кафедра екології

Напрям (спеціальність, спеціалізація): спеціальність 101м «Екологія», спеціалізація «Екологія та охорона навколишнього середовища»

(шифр, найменування)

ЗАТВЕРДЖУЮ
Завідувач кафедри
___________Фролов В.Ф.
«____» _________ 2020 р.

ЗАВДАННЯ
на виконання дипломної роботи
Білецького Ростислава Віталійовича

1. Тема роботи «» затверджена наказом ректора від «11» жовтня 2019 р. №2364/ст.

2. Термін виконання роботи: з 14.10.2019 р. по 09.02.2020 р.

3. Вихідні дані роботи: дані накопичення відходів.

4. Зміст пояснювальної записки: проаналізувати проблеми накопичення відходів у світі та в Україні, дослідити існуючі методи утилізації відходів, запропонувати альтернативну технологію переробки ТПВ у будівництві, скласти практичні рекомендації щодо застосування запропонованої технології.

5. Перелік обов’язкового графічного (ілюстративного) матеріалу: таблиці, рисунки.

6. Календарний план-графік

№ з/п	Завдання	Термін виконання	Підпис керівника
1	Отримання завдання, пошук літературних джерел по темі, напрацювання методології роботи	18.10.2019 – 20.10.2019	
2	Підготовка основної частини (Розділ I)	21.10.2019 – 10.11.2019	
3	Підготовка основної частини (Розділ II)	10.11.2019 – 17.11.2019	
4	Підготовка основної частини (Розділ III) та підготовка до першого попереднього захисту	17.11.2019 – 15.12.2019	
5	Перше попереднє представлення роботи на кафедрі	16.12.2019	
6	Підготовка основної частини (Розділ IV)	16.12.2019 – 28.12.2019	
7	Формулювання висновків	02.01.2020 – 09.01.2020	
8	Складання пояснювальної записки до другої попередньої презентації	10.01.2020 – 22.01.2020	
9	Друге попереднє представлення роботи на кафедрі	23.01.2020	
10	Формулювання висновків та рекомендацій, косметичні правки, консультація з нормоконтролером, урахування зауважень	23.01.2020 – 26.01.2020	
11	Дооформлення, отримання підписів, перевірка на плагіат, підготовка до захисту	27.01.2020 – 04.02.2020	
12	Захист готової роботи на кафедрі	05.02.2020	

7. Консультація з окремого(мих) розділу(ів):

Розділ	Консультант (посада, П.І.Б.)	Дата, підпис	
		Завдання видав	Завдання прийняв
Охорона праці	Коваленко В. В., к.б.н., доцент каф. цивільної та промислової безпеки		

8. Дата видачі завдання: «____» _________ 20__ р.

Керівник дипломної роботи (проекту): ________________ Павлюх Л.І.
(підпис керівника) (П.І.Б.)

Завдання прийняв до виконання: ________________ Білецький Р.В.
(підпис випускника) (П.І.Б.)

ABSTRACT

Explanatory note to thesis « Organization of SDW recycling in the construction industry »: 108 pages, 27 figures, 4 tables, 42 references.

Object of research: waste management.

Subject of research: municipal solid waste recycling in construction industry.

Aim of research: to development technology of MSW recycling in construction industry.

Methods of research: statistical, analytical, comparison, analysis and synthesis.

The results of the study are recommended for the organization of the reuse of municipal waste in the construction industry with the aim of preventing disposal on landfills and, as a consequence, environmental pollution.

MUNISIPAL SOLID WASTE, RECYCLING, ARMATURE, CONSTRUCTION INDUSTRY, ENVIRONMENT QUALITY.

РЕФЕРАТ

Пояснювальна записка до дипломної роботи «Організація повторного використання ТПВ у будівельній галузі»: 108с., 28 рисунків, 4 таблиць, 42 літературних джерела.

Об’єкт дослідження: поводження з відходами.

Предмет дослідження: повторне використання твердих побутових відходів у будівельній галузі.

Мета роботи: розробити технологію повторного використання твердих побутових відходів у будівельній галузі.

Методи дослідження: статистичні, аналітичні, порівняння, аналіз та синтез.

Результати дослідження рекомендовані для організації повторного використання побутових відходів в будівельній галузі з метою попередження їх потрапляння на сміттєзвалища та, як наслідок, забруднення довкілля.

ТВЕРДІ ПОБУТОВІ ВІДХОДИ, ПОВТОРНЕ ВИКОРИСТАННЯ, АРМАТУРА, БУДІВЕЛЬНА ГАЛУЗЬ, ЯКІСТЬ НАВКОЛИШНЬОГО СЕРЕДОВИЩА.

CONTENT

LIST OF SYMBOLS, ABBREVIATIONS AND TERMS

MSW – Municipal Solid Wastes;

WB - World Bank;

UNFCCC - United Nations Framework Convention on Climate Change;

AMCU - Antimonopoly Committee of Ukraine;

CMU - Cabinet of Ministers of Ukraine;

EU - European Union;

AES - Alternative Energy Sources;

BAU - Bioenergy Association of Ukraine;

EBA - European Business Association;

KSCA - Kiev City State Administration;

NKREKU - National Commission for State Regulation in the Sphere of Energy and Utilities;

RDF - Refuse derived fuel;

SRF - Solid recovered fuel;

PET - Polyethylene terephthalate;

ETRA - European Tire Recycling Association;

GOST - National standard (of Soviet Union).

INTRODUCTION

Relevance. The world generates 2.01 billion tonnes of municipal solid waste annually, with at least 33 percent of that – extremely conservatively – not managed in an environmentally safe manner. Worldwide, waste generated per person per day averages 0.74 kilogram but ranges widely, from 0.11 to 4.54 kilograms. One of the main reason of environmental pollution is the lack of an efficient system for collecting and sorting certain types of waste at the regional level as secondary raw materials. At present, only about 20% of all recyclable material are involved in economic turnover. As a result, a significant amount of materials that have a resource value and are recyclable (glass, paper, plastic, textiles, rubber) fall into landfills.

Aim and tasks of graduate work. The aim of the work to development technologies of MSW recycling in construction industry.

Tasks of work:

1. To analyze the waste accumulation in the World and in Ukraine;
2. To investigate the current technologies MSW recycling;
3. To develop technology of MSW recycling in construction industry.

Object – waste management.

Subject – municipal solid waste recycling in construction industry.

Methods of research. statistical, analytical, comparison, analysis and synthesis.

Scientific novelty of the results.

1) Further development of municipal solid waste recycling in construction industry was gained.

2) For the first time, the waste recycling to alternative type of armature production was proposed.

The practical value of the results obtained. The results of the study are recommended for the organization of the reuse of municipal waste in the construction industry with the aim of preventing disposal on landfills and, as a consequence, environmental pollution.

Personal contribution of the graduate. Analysis of technologies for waste recycling was conducted, the technology to alternative type of armature production was proposed.

CHAPTER 1
ANALYSIS OF WASTE GENERATION

The world generates 2.01 billion tonnes of municipal solid waste annually, with at least 33 percent of that – extremely conservatively – not managed in an environmentally safe manner. Worldwide, waste generated per person per day averages 0.74 kilogram but ranges widely, from 0.11 to 4.54 kilograms. Though they only account for 16 percent of the world's population, high-income countries generate about 34 percent, or 683 million tonnes, of the world's waste [1].

1.1 Waste accumulation issues in the World

When looking forward, global waste is expected to grow to 3.40 billion tonnes by 2050, more than double population growth over the same period. Overall, there is a positive correlation between waste generation and income level. Daily per capita waste generation in high-income countries is projected to increase by 19 percent by 2050, compared to low- and middle-income countries where it is expected to increase by approximately 40% or more. Waste generation initially decreases at the lowest income levels and then increases at a faster rate for incremental income changes at low income levels than at high income levels. The total quantity of waste generated in low-income countries is expected to increase by more than three times by 2050 [1] (Fig.1.1).

The East Asia and Pacific region is generating most of the world's waste, at 23 percent, and the Middle East and North Africa region is producing the least in absolute terms, at 6 percent. However, the fastest growing regions are Sub-Saharan Africa, South Asia, and the Middle East and North Africa, where, by 2050, total waste generation is expected to more than triple, double, and double respectively. In these regions, more than half of waste is currently openly dumped, and the trajectories of waste growth will have vast implications for the environment, health, and prosperity, thus requiring urgent action.

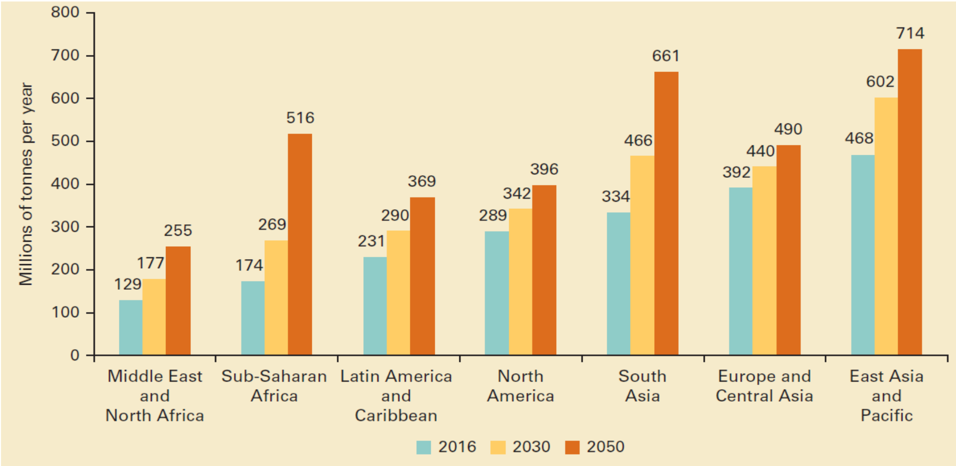


Fig.1.1 Projected waste generation, by region (millions of tonnes/year)

Waste collection is a critical step in managing waste, yet rates vary largely by income levels, with upper-middle- and high-income countries providing nearly universal waste collection. Low-income countries collect about 48 percent of waste in cities, but this proportion drops drastically to 26 percent outside of urban areas. Across regions, Sub-Saharan Africa collects about 44 percent of waste while Europe and Central Asia and North America collect at least 90 percent of waste [2] (Fig. 1.2.)

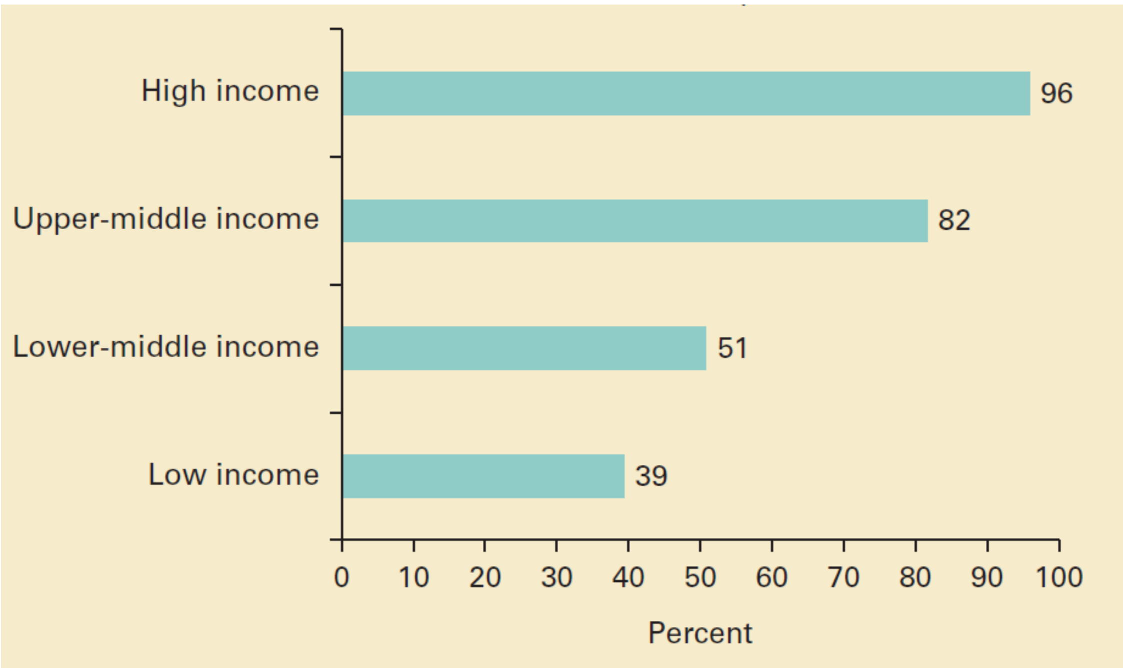


Fig. 1.2 Waste collection rates, by income level (percent)

Waste composition differs across income levels, reflecting varied patterns of consumption. High-income countries generate relatively less food and green waste, at 32 percent of total waste, and generate more dry waste that could be recycled, including plastic, paper, cardboard, metal, and glass, which account for 51 percent of waste. Middle- and low-income countries generate 53 percent and 57 percent food and green waste, respectively, with the fraction of organic waste increasing as economic development levels decrease. In low-income countries, materials that could be recycled account for only 20 percent of the waste stream. Across regions, there is not much variety within waste streams beyond those aligned with income. All regions generate about 50 percent or more organic waste, on average, except for Europe and Central Asia and North America, which generate higher portions of dry waste [1] (Fig. 1.3).

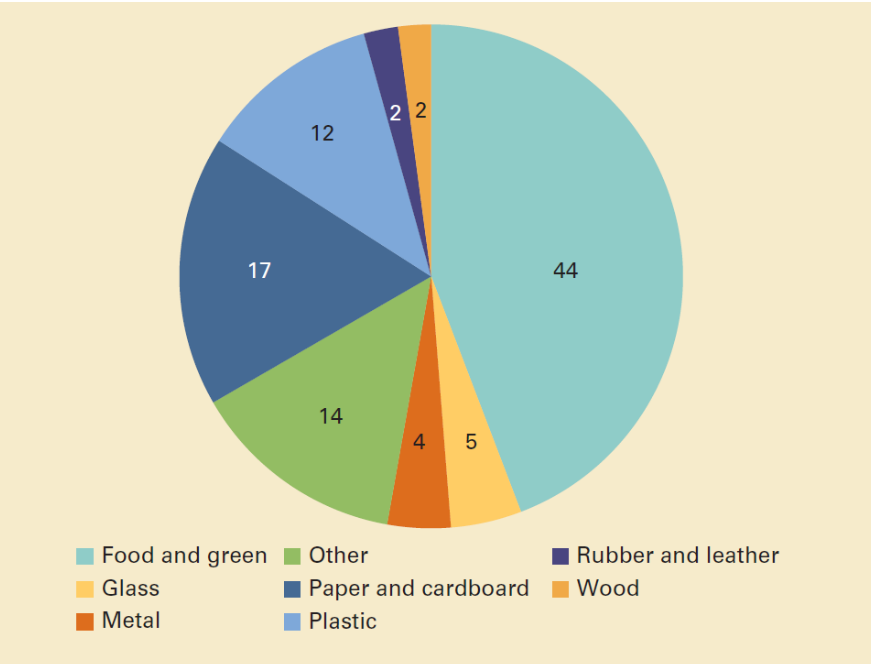
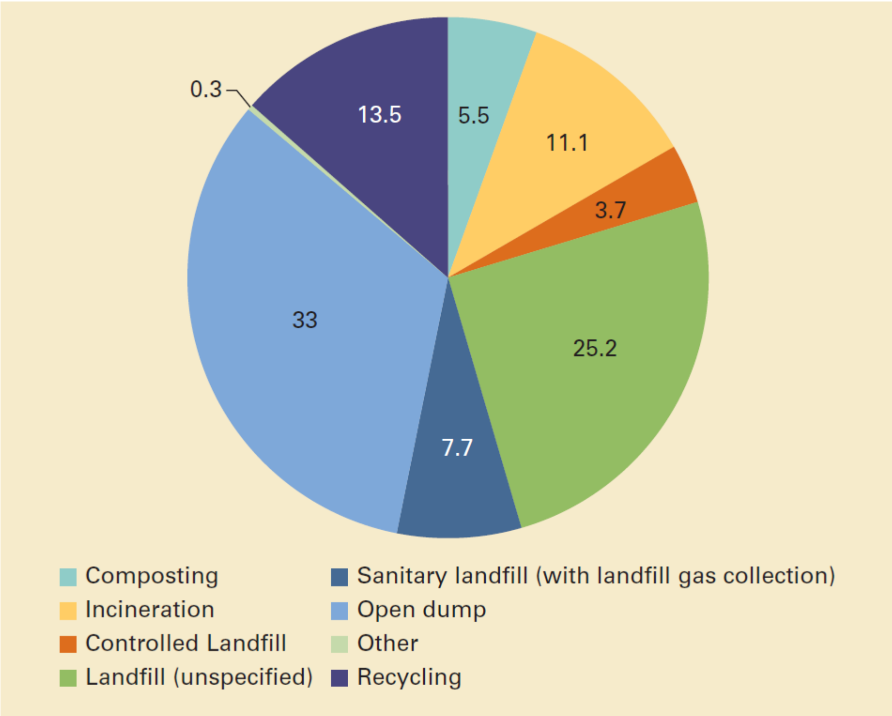


Fig. 1.3 Global waste composition (percent)

It is a frequent misconception that technology is the solution to the problem of unmanaged and increasing waste. Technology is not a panacea and is usually only one factor to consider when managing solid waste. Countries that advance from open dumping and other rudimentary waste management methods are more likely to succeed when they select locally appropriate solutions. Globally, most waste is currently dumped or disposed of in some form of a landfill. Some 37 percent of waste is disposed of in some form of a landfill, 8 percent of which is disposed of in sanitary landfills with landfill gas collection systems. Open dumping accounts for about 31 percent of waste, 19 percent is recovered through recycling and composting, and 11 percent is incinerated for final disposal [1] (Fig.



1.4). Adequate waste disposal or treatment, such as controlled landfills or more stringently operated facilities, is almost exclusively the domain of high- and upper-middle-income countries.

Fig. 1.4 Global treatment and disposal of waste (percent)

Lower-income countries generally rely on open dumping; 93 percent of waste is dumped in low-income countries and only 2 percent in high-income countries. Three regions openly dump more than half of their waste—the Middle East and North Africa, Sub-Saharan Africa, and South Asia. Upper-middle-income countries have the highest percentage of waste in landfills, at 54 percent. This rate decreases in high-income countries to 39 percent, with diversion of 36 percent of waste to recycling and composting and 22 percent to incineration [1]. Incineration is used primarily in high-capacity, high-income, and land-constrained countries.

Based on the volume of waste generated, its composition, and how it is managed, it is estimated that 1.6 billion tonnes of carbon dioxide (CO_2) equivalent greenhouse gas emissions were generated from solid waste treatment and disposal in 2016, or 5 percent of global emissions. This is driven primarily by disposing of waste in open dumps and landfills without landfill gas collection systems. Food waste accounts for nearly 50% of emissions. Solid waste–related emissions are anticipated to increase to 2.38 billion tonnes of CO_2-equivalent per year by 2050 if no improvements are made in the sector [1].

In most countries, solid waste management operations are typically a local responsibility, and nearly 70 percent of countries have established institutions with responsibility for policy development and regulatory oversight in the waste sector. About two-thirds of countries have created targeted legislation and regulations for solid waste management, though enforcement varies drastically. Direct central government involvement in waste service provision, other than regulatory oversight or fiscal transfers, is uncommon, with about 70 percent of waste services being overseen directly by local public entities. At least half of services, from primary waste collection through treatment and disposal, are operated by public entities and about one-third involve a public-private partnership. However, successful partnerships with the private sector for financing and operations tend to succeed only under certain conditions with appropriate incentive structures and enforcement mechanisms, and therefore they are not always the ideal solution [2].

Financing solid waste management systems is a significant challenge, even more so for ongoing operational costs than for capital investments, and operational costs need to be taken into account upfront. In high-income countries, operating costs for integrated waste management, including collection, transport, treatment, and disposal, generally exceed $100 per tonne. Lower-income countries spend less on waste operations in absolute terms, with costs of about $35 per tonne and sometimes higher, but these countries experience much more difficulty in recovering costs. Waste management is labor intensive and costs of transportation alone are in the range of $20–$50 per tonne. Cost recovery for waste services differs drastically across income levels. User fees range from an average of $35 per year in low-income countries to $170 per year in high-income countries, with full or nearly full cost recovery being largely limited to high-income countries. User fee models may be fixed or variable based on the type of user being billed. Typically, local governments cover about 50 percent of investment costs for waste systems, and the remainder comes mainly from national government subsidies and the private sector [2].

1.2 Waste accumulation issues in Ukraine

With the rapid growth of consumption in the world, the problem of handling accumulated waste becomes more and more urgent. Millions of tons of solid waste accumulate annually at numerous landfills in cities. When decomposed, they poison air, soil, groundwater and are a huge danger to the environment and humans.

Urban solid waste is called "municipal waste" and was called waste, the burial of which was mainly carried out by the city authorities. However, at present, in developed countries, a significant amount of household waste is collected and not processed by municipal utilities, but by private enterprises, which also deal with industrial waste. As the quantity and variety of waste increased, and the relations associated with their disposal became more complicated, various classifications and definitions of waste types were developed. Some of them were the basis of national laws governing the treatment of various types of waste [5].

According to static estimates, the average annual amount of MSW per capita in Ukraine is 225 - 250 kg per year, which is about 10 million tons or almost 30 million m2. But at the same time, solid waste landfills contain many valuable components that can and should be used for further processing to obtain useful products and socio-economic benefits [5].

The composition and properties of household waste are extremely diverse and depend not only on the level of consumption of the country and area, time of year, and on many other factors (Fig. 1.5).

The amount of municipal waste in Ukraine is increasing, and its composition, especially in megacities (Kiev, Kharkov, Donetsk, Dnepropetrovsk, Odessa) is approaching the composition of solid waste in developed countries with a relatively large share of paper waste and plastic [6].

The processes taking place in Ukraine at present lead to a sharp increase in the quantity and variety of household waste. Responsibility for their disposal is shifted to local authorities, and this leads to the fact that it is virtually impossible to locate MSW disposal facilities on administratively “alien” territories - no one wants to be responsible for “garbage” problems [5].

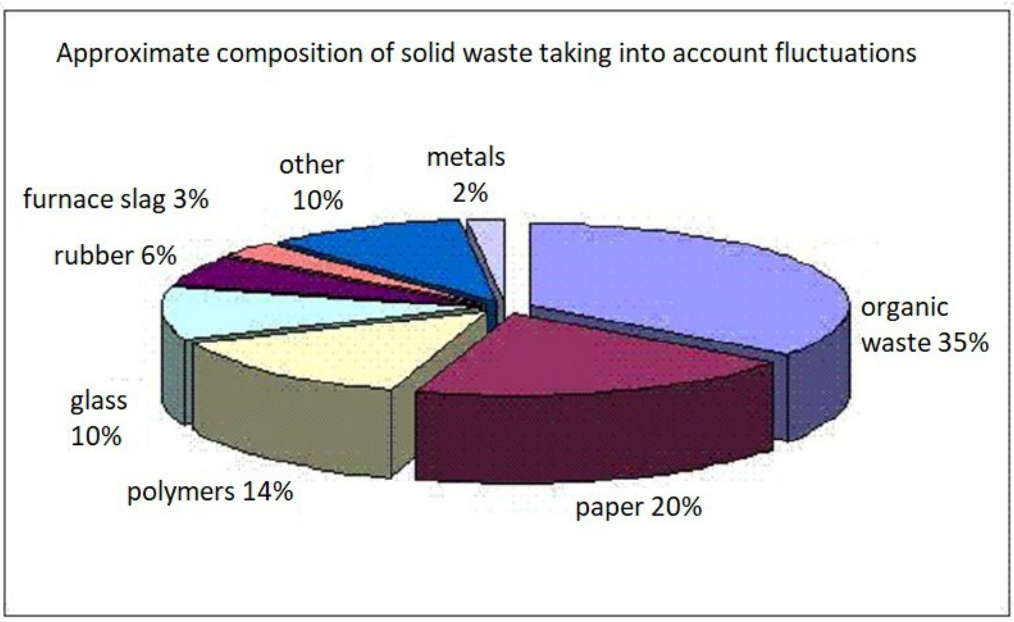


Fig. 1.5. Waste distribution by category in different countries

The National Waste Management Strategy adopted in 2017 prescribed that the amount of solid waste disposed at landfills should be reduced from 95% (in 2016) to 50% in 2023 and to 30% in 2030. However, last year's indicator does not keep up with the set pace: the amount of waste disposed of in 2018 decreased by only 1.2%. According to experts, the situation in the field of waste management will not change dramatically until the sorting and processing of garbage becomes a profitable business for investors [6].

On the thorny path to the EU, Ukraine has to go through many metamorphoses in all sectors of life. In matters of membership, the EU is adamant: our area of waste management should be brought to the European quality mark. For this, the government of Ukraine in 2017 developed a clear and consistent plan - the National Strategy for Waste Management until 2030 [5].

According to EU Directives, the "garbage policy" should primarily be reduced to minimizing its formation, and landfill should be a last resort and should only concern waste that is not biodegradable, cannot be used as recyclables and recycled into energy.

In Sweden, Norway, Denmark, the Netherlands and other countries where the waste management sector is maximized, less than 5% of landfills are in municipal solid waste (MSW). Everything that is possible is squeezed out of the garbage. In Ukraine, more than 93% fall into landfills. At the same time, the Law "On Waste" prohibits from January 1, 2018, disposing of unprocessed solid waste at landfills.

"In fact, what comes to our landfill has already been sorted. Of the total volume of municipal solid waste, a maximum of 5% is a commodity item, that is, what recycling centers can accept and recycle. Nobody needs the rest.

And in order to dispose of this waste with processing into energy, there are no enterprises in Ukraine, except for the metropolitan Energy plant. Therefore, we get such a large percentage of burial at the landfill, "explains Andrei Gruschinsky, director of the company-operator of the landfill for solid waste № 5 of Kyivspectrans PJSC [5].

According to the Ministry of Regional Development, Construction and Housing and Communal Services, 4.2% of landfills in Ukraine are full, 16% do not meet environmental safety standards, and 30% need certification.

At the same time, a quarter of the population is still not covered by the garbage collection service, and natural dumps continue to arise here and there like mushrooms after rain: according to official statistics, about 26 thousand of them are formed annually.

Finding money in the local budget for the construction of new landfills and waste recycling complexes is an almost impossible task: their cost ranges from tens of millions of hryvnias to tens of millions of dollars. Despite the fact that the Law Office "On Housing and Communal Services" regulates that now Ukrainians must pay not only for the disposal and disposal of garbage, but also for its processing, local authorities are in no hurry to raise the tariff: it can grow by 100-200 hrn, and this is far from affordable for everyone.

The most optimal solution, according to participants in the waste management sector, would be to introduce into the legislation norms on the expanded liability of manufacturers of containers and packaging or environmental taxes. But these draft laws, as amended, do not suit residents of the EU Delegation to Ukraine, the European Business Association, the American Chamber of Commerce, the All-Ukrainian Agrarian Council and other business representatives [5].

In Ukraine, there are 6.5 thousand legal and about 35 thousand illegal landfills with a total area of 7% of the territory, and this can be equated to the entire territory of Denmark (more than 43 thousand sq. Km). And every year the situation is only getting worse. According to environmentalists, Ukraine has accumulated 54 million cubic meters of waste; annually about 15-17 million tons of landfills are replenished. Only a tenth of the collected garbage is recycled [7].

Today in the country there are 4 waste incineration plants: in Kiev, Dnepropetrovsk, Kharkov and occupied Sevastopol. But only the Kiev factory Energy works.

Garbage has nowhere to go, because it will decay for hundreds of years. And even if you start sorting and processing it, vast territories of fertile land will be restored no sooner than after 300 years [7].

In rural areas, there are no sanitation schemes, there are no containers for collecting municipal solid waste, and there is no collection and disposal of waste. There are one or two authorized landfills in district centers, which require funds to transport waste. Ineffective environmental control regarding waste management, low environmental awareness of residents. Therefore, in villages people take out garbage to the forest or to the river,

- tells the ecologist of the international charity organization "Ecology-Law-Man" Alla Voitsikhovskaya.

The tragedy of May 28 at the Gribovitsky landfill near Lviv once again reminded the country of global environmental problems. Almost every settlement has problems with waste, and the sphere of waste disposal as such in Ukraine actually does not exist [7].

1.3 Waste Management Strategy

The World Bank finances and advises on solid waste management projects using a diverse suite of products and services, including traditional loans, results-based financing, development policy financing, and technical advisory. World Bank-financed waste management projects address the entire lifecycle of waste-from generation to collection and transportation, and finally treatment and disposal [2]. Objectives that guide the Bank's solid waste management projects and investments include:

- ✓ Infrastructure: The World Bank provides capital investments to build or upgrade waste sorting and treatment facilities, close dumps, construct or refurbish landfills, and provide bins, dumpsters, trucks, and transfer stations.
- ✓ Legal structures and institutions: Projects advise on sound policy measures and coordinated institutions for the municipal waste management sector.
- ✓ Financial sustainability: Through the design of taxes and fee structures, and long-term planning, projects help governments improve waste cost containment and recovery.
- ✓ Citizen engagement: Behavior change and public participation is key to a functional waste system. The World Bank supports designing incentives and awareness systems to motivate waste reduction, source-separation and reuse.
- ✓ Social inclusion: Resource recovery in most developing countries relies heavily on informal workers, who collect, sort, and recycle 15%–20% of generated waste. Projects address waste picker livelihoods through strategies such as integration into the formal system, as well as the provision of safe working conditions, social safety nets, child labor restrictions, and education.

✓ Climate change and the environment: Projects promote environmentally sound waste disposal. They support greenhouse gas mitigation through food loss and waste reduction, organic waste diversion, and the adoption of treatment and disposal technologies that capture biogas and landfill gas. Waste projects also support resilience by reducing waste disposal in waterways, addressing debris management, and safeguarding infrastructure against flooding.

✓ Health and safety: The World Bank's work in municipal waste management improves public health and livelihoods by reducing open burning, mitigating pest and disease vector spreading, and preventing crime and violence.

✓ Knowledge creation: The World Bank helps governments plan and explore locally appropriate solutions through technical expertise, and data and analytics. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050 captures the latest trends in waste management [3].

The World Bank's waste management engagement spans multiple development areas, including energy, environmental sustainability, food and agriculture, health and population, social protection, transportation, urban development, and water.

1.4 Waste Management Incomes

Since 2000, the World Bank has committed over $4.7 billion to more than 340 solid waste management programs in all six regions of World Bank engagement. Recent or committed infrastructure lending and technical assistance have supported numerous initiatives, including:

- *East Asia and the Pacific*

In Indonesia, a $100 million loan will support a $1 billion national program to reform waste management practices for around 70 participating cities, impacting around 50 million people. The loan will support the strengthening of local policies and institutions, closure and rehabilitation of old and informal dumpsites, and installation of sustainable disposal sites including modern sanitary landfills with landfill gas collection mechanisms [3].

In China, a results-based incentive program has motivated household kitchen waste separation. The $80 million loan has also supported the construction of a modern anaerobic digestion facility to ferment and recover energy from organic waste, which will benefit 3 million people.

In Vietnam, investments in solid waste management are helping the city of Can Tho prevent clogging of drains, which could result in flooding. Similarly, in the **Philippines**, investments are helping Metro Manila reduce flood risk by minimizing solid waste ending up in waterways. By focusing on improved collection systems, community-based approaches, and providing incentives, the waste management investments are contributing to reducing marine litter, particularly in Manila Bay [3].

- *Europe and Central Asia*

In Belarus, $25 million of a WB loan is supporting the introduction of a regional approach to solid waste management. The loan aims to support construction of regional waste management facilities and closure of relevant dumpsites, and provide technical assistance to the sector more broadly.

In Azerbaijan, WB loans supported the rehabilitation of the main landfill site and establishment of a state-owned waste management company, increasing the population served by the formal solid waste management system from 53% in 2008 to 74% in 2012. Support also led to further sustainable waste management practices, helping achieve a 25% recycling and reuse rate [3].

In Bosnia and Herzegovina, WB loans financed the rehabilitation of existing disposal sites, development of regional landfills, wild dump closures, and supportive equipment. Through the infrastructure investments and technical assistance on SWM issues, the loans helped increase access to the formal waste management system from 25% to 66% of the population [4].

- *Latin America and the Caribbean*

In Argentina, $40 million in loans and grants helped to reduce and properly treat food waste through partnerships with food banks and retailers, close over 70 dumpsites, and construct 11 waste facilities [4].

In Sint Maarten, the WB is providing a $25 million grant for emergency debris management with a focus on dumpsite management, in addition to broader sectoral support. There is ongoing support to develop a national solid waste management strategy and investment plans to further develop the solid waste management sector in an integrated manner [4].

In Jamaica, community participation and waste collection services improved in 18 communities through results-based financing and infrastructure investments. Waste activities also led to job creation and contributed to a crime prevention and reduction program [4].

- *Middle East and North Africa*

In Morocco, a series of Development Policy Loans totaling $500 million improved citizen engagement and transparency, strengthened private sector partnerships and accountability, increased fee collection, and supported better working conditions for—and the social inclusion of—20,000 informal workers [4].

In the West Bank, loans have supported the construction of three landfill sites that serve over 2 million residents, enabled dump closure, developed sustainable livelihood programs for waste pickers, and linked payments to better service delivery through results-based financing [4].

- *South Asia*

In Nepal, a results-based financing project of $4.3 million increased user fee collection and improved waste collection services in five municipalities, benefitting 800,000 residents [3].

In Pakistan, a $5.5 million dollar project supported a composting facility in Lahore in market development and the sale of emission reduction credits under the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). Activities resulted in reductions of 150,000 tonnes of carbon dioxide equivalents and expansion of daily compost production volume from 300 to 1000 tonnes per day [3, 4].

- *Sub-Saharan Africa*

In Liberia, $10.5 million has been committed to improve waste collection and construct a new sanitary landfill and transfer stations.

In Burkina Faso, the WB has supported the solid waste sector with over $67 million in loans since 2005, supporting waste sector planning and construction of two landfills. The capital city, Ouagdougou, now collects an average of 78% of waste generated, which is significantly higher than the 46% average in Sub-Saharan Africa [4].

1.5. Conclusion to Chapter 1

This section addresses the issue of garbage collapse. Outlines the extent of the problem and describes how global the problem is as a whole. Also how much garbage is recycled was analyzed and the comparison with how much garbage is produced was conducted.

The next chapter will be devoted to waste recycling methods investigation.

CHAPTER 2
IVESTIGATION OF WASTE RECYCLING METHODS

2.1 Classification of waste

Waste management which has always formed part of the human society consists of waste prevention, reuse, recycling of materials, composting, energy recovery and final disposal. The mushrooming of the world's population, increasing industrialization, improving quality of life, and developments in technology have all resulted in an increase in both the quantity and the different types of solid wastes generated by industries, households and other activities (UNEP,1991). The problems of dealing with large amount of waste materials arise specially in developing countries where these changes have not been met by developments in waste-management technologies. Domestic solid waste has become a health and environmental hazard in many developing countries as a result of careless handling and a failure to make arrangement for appropriate solid waste collection techniques. It is a common belief that improving solid waste management (SWM) implies making waste collection and disposal systems more efficient, raising residents' awareness and enforcing SWM laws and regulations [42].

Solid waste can be defined as "a different types of solid materials and also some liquids in cans, that are disposed as being spent, useless, worthless or in excess" [42].

The classification of solid waste is based on the content, moisture and heating value. An example of classification is as follows:

Garbage refers to the biodegradable solid waste constituents, obtained during the preparation or storage of food (meat, fruits, and vegetables). These wastes water content of about 70% and a heating value of around 6ooooookg.

Rubbish refers to non-putrecible solid waste constituents either combustible (paper, wood, scrap) or non-combustible (metals, glasses ceramics). These wastes contain about 25% of water and the heating value of the waste is around 15000000kg [42].

Solid waste can be classified into different types depending on their source (Fig. 2.1):

- Household waste is generally classified as municipal waste,
- Industrial waste as hazardous waste, and
- Biomedical waste or hospital waste as infectious waste.

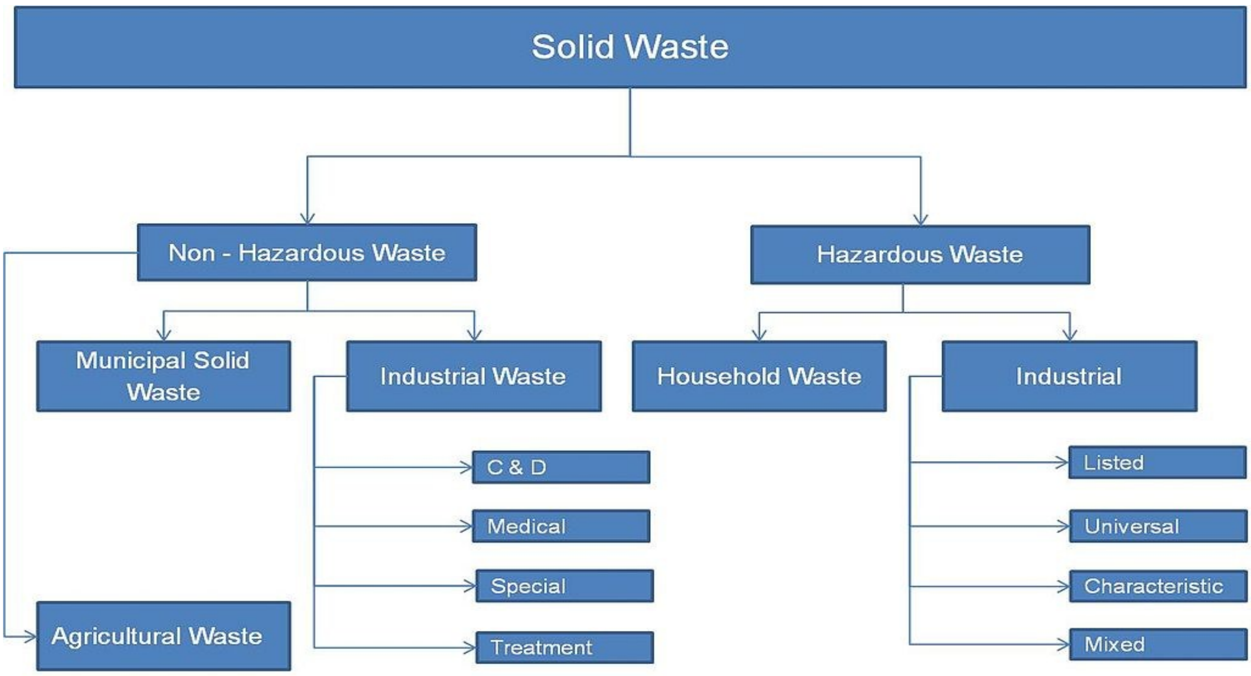


Fig. 2.1. Major Classification of Solid Waste

Municipal solid waste. Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. This garbage is generated mainly from residential and commercial complexes. With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing. In 1947 cities and towns in

India generated an estimated 6 million tonnes of solid waste, in 1997 it was about 48 million tonnes. More than 25% of the municipal solid waste is not collected at all; 70% of the Indian cities lack adequate capacity to transport it and there are no sanitary landfills to dispose of the waste. The existing landfills are neither well equipped or well managed and are not lined properly to protect against contamination of soil and groundwater.

Over the last few years, the consumer market has grown rapidly leading to products being packed in cans, aluminium foils, plastics, and other such nonbiodegradable items that cause incalculable harm to the environment. In India, some municipal areas have banned the use of plastics and they seem to have achieved success. For example, today one will not see a single piece of plastic in the entire district of Ladakh where the local authorities imposed a ban on plastics in 1998. Other states should follow the example of this region and ban the use of items that cause harm to the environment. One positive note is that in many large cities, shops have begun packing items in reusable or biodegradable bags. Certain biodegradable items can also be composted and reused. In fact proper handling of the biodegradable waste will considerably lessen the burden of solid waste that each city has to tackle.

There are different categories of waste generated, each take their own time to degenerate (as illustrated in the table below).

Hazardous waste. Industrial and hospital waste is considered hazardous as they may contain toxic substances. Certain types of household waste are also hazardous. Hazardous wastes could be highly toxic to humans, animals, and plants; are corrosive, highly inflammable, or explosive; and react when exposed to certain things e.g. gases**.** India generates around 7 million tonnes of hazardous wastes every year, most of which is concentrated in four states: Andhra Pradesh, Bihar, Uttar Pradesh, and Tamil Nadu.

Household waste that can be categorized as hazardous waste include old batteries, shoe polish, paint tins, old medicines, and medicine bottles.

Hospital waste contaminated by chemicals used in hospitals is considered hazardous. These chemicals include formaldehyde and phenols, which are used as disinfectants, and mercury, which is used in thermometers or equipment that measure blood pressure. Most hospitals in India do not have proper disposal facilities for these hazardous wastes.

In the industrial sector, the major generators of hazardous waste are the metal, chemical, paper, pesticide, dye, refining, and rubber goods industries.

Direct exposure to chemicals in hazardous waste such as mercury and cyanide can be fatal.

Hospital waste. Hospital waste is generated during the diagnosis, treatment, or immunization of human beings or animals or in research activities in these fields or in the production or testing of biologicals. It may include wastes like sharps, soiled waste, disposables, anatomical waste, cultures, discarded medicines, chemical wastes, etc. These are in the form of disposable syringes, swabs, bandages, body fluids, human excreta, etc. This waste is highly infectious and can be a serious threat to human health if not managed in a scientific and discriminate manner. It has been roughly estimated that of the 4 kg of waste generated in a hospital at least 1 kg would be infected.

Surveys carried out by various agencies show that the health care establishments in India are not giving due attention to their waste management. After the notification of the Bio-medical Waste (Handling and Management) Rules, 1998, these establishments are slowly streamlining the process of waste segregation, collection, treatment, and disposal. Many of the larger hospitals have either installed the treatment facilities or are in the process of doing so.

2.2 Waste Disposal Methods

Industrialized nations are grappling with the problem of expeditious and safe waste disposal. Non-biodegradable and toxic wastes like radioactive remnants can potentially cause irreparable damage to the environment and human health if not strategically disposed of.

Though waste disposal has been a matter of concern for several decades, the main problem has been taking massive proportions due to growth in population and industrialization, the two major factors that contribute to waste generation. Though some advancement is being made in waste disposal methods, they are still not adequate. The challenge is to detect newer and unhazardous methods of waste disposal and put these methods to use (Fig. 2.2).

- *Preventing or reducing waste generation:* Extensive use of new or unnecessary products is the root cause of unchecked waste formation. The rapid

population growth makes it imperative to use secondhand products or judiciously use the existing ones because if not, there is a potential risk of people succumbing to the ill effects of toxic wastes. Disposing of the wastes will also assume formidable shape. A conscious decision should be made at the personal and professional level to judiciously curb the menacing growth of wastes.

Fig. 2.1. Waste Disposal Activity

- *Recycling:* Recycling serves to transform the wastes into products of their own genre through industrial processing. Paper, glass, aluminum, and plastics are commonly recycled. It is environmentally friendly to reuse the wastes instead of adding them to nature. However, processing technologies are pretty expensive.
- *Incineration:* Incineration features combustion of wastes to transform them into base components, with the generated heat being trapped for deriving energy. Assorted gases and inert ash are common by-products. Pollution is caused by varied degrees

dependent on nature of waste combusted and incinerator design. Use of filters can check pollution. It is rather inexpensive to burn wastes and the waste volume is reduced by about 90% [2]. The nutrient rich ash derived out of burning organic wastes can facilitate hydroponic solutions. Hazardous and toxic wastes can be easily be rid of by using this method. The energy extracted can be used for cooking, heating, and supplying power to turbines. However, strict vigilance and due diligence should be exercised to check the accidental leakage of micro level contaminants, such as dioxins from incinerator lines. In Fig. 2.3 some waste disposal methods are shown.

Composting   Sanitary Landfills   Waste Disposal in Ocean

Fig. 2.3. Waste Disposal

- *Composting:* It involves decomposition of organic wastes by microbes by allowing the waste to stay accumulated in a pit for a long period of time. The nutrient rich compost can be used as plant manure. However, the process is slow and consumes a significant amount of land. Biological reprocessing tremendously improves the fertility of the soil.
- *Sanitary Landfill:* This involves the dumping of wastes into a landfill. The base is prepared of a protective lining, which serves as a barrier between wastes and ground water, and prevents the separation of toxic chemicals into the water zone. Waste layers are subjected to compaction and subsequently coated with an earth layer. Soil that is

non-porous is preferred to mitigate the vulnerability of accidental leakage of toxic chemicals. Landfills should be created in places with low groundwater level and far from sources of flooding. However, a sufficient number of skilled manpower is required to maintain sanitary landfills.

- *Disposal in ocean/sea:* Wastes generally of radioactive nature are dumped in the oceans far from active human habitats. However, environmentalists are challenging this method, as such an action is believed to spell doom for aquatic life by depriving the ocean waters of its inherent nutrients [2].

2.3 Garbage Disposal in Ukraine

99% of functioning landfills do not meet European requirements, and every third violates environmental safety standards. Only 5.8% of garbage in Ukraine goes for recycling. Such data has recently been published by the Antimonopoly Committee of Ukraine [8]. In the Fig. 2.4 the variety of waste is demonstrated.

Fig. 2.4. Waste Variety

In total, according to the AMCU, in 2016, the inhabitants of Ukraine created 49 million cubic meters of garbage, or 11 million tons. The vast majority of garbage goes straight to landfills - 94.2%. Thus, one resident of Ukraine accounts for up to 300 kg of garbage per year [8].

According to data, only 2.8 million cubic meters of garbage are processed in Ukraine. The situation with landfills in Ukraine is catastrophic. Thus, according to expert estimates, 99% of functioning landfills do not meet European requirements, and 30% of almost 5.5 thousand landfills do not meet domestic environmental safety standards [9] (Fig. 2.5).

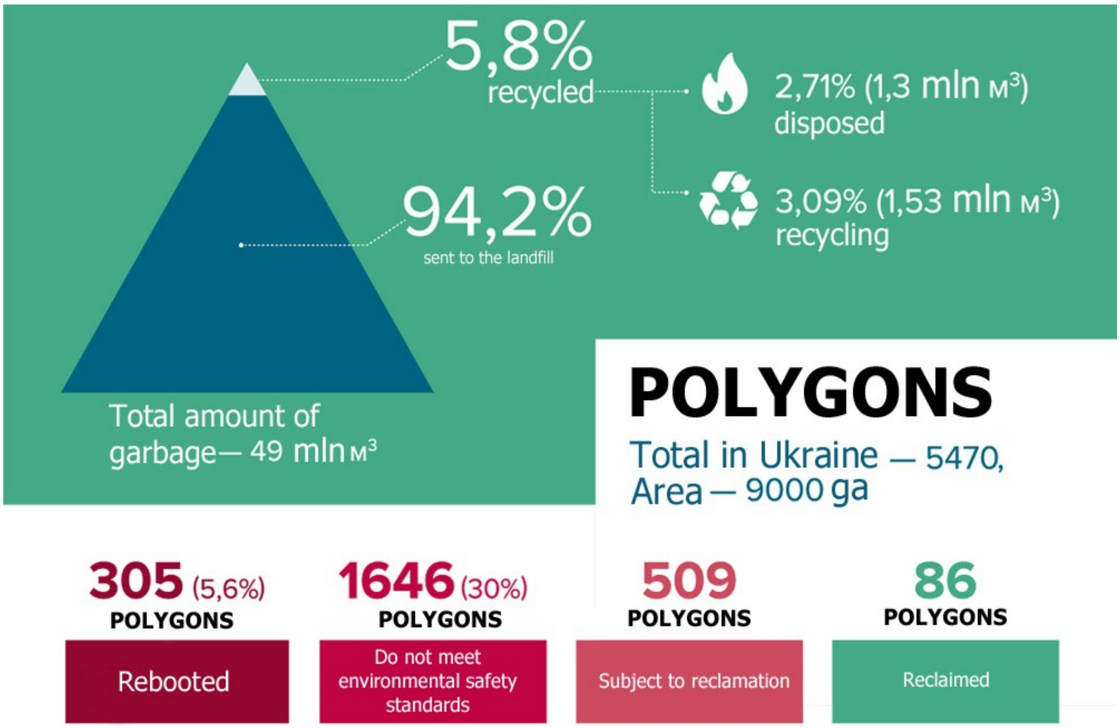


Fig. 2.5. Recycling in Ukraine in Numbers (2016)

According to the AMCU, 5.6% of landfills in Ukraine are overloaded. Most of the landfills in Ukraine operate in overload mode: in violation of design indicators of waste accumulation volumes [8].

According to experts, now Ukraine needs to build at least 443 new landfills.

Because of this, natural dumps have become quite common in Ukraine. In 2016, 27.5 thousand unauthorized landfills were officially counted in Ukraine, which occupied an area of 1.2 thousand hectares. Almost all of them were eliminated, the AMCU report says [5, 8].

Most of all in Ukraine, residents of the Transcarpathian region pay for transportation and burial of garbage, and least of all - in the Zhytomyr region.

On average, residents of Ukraine pay 54.5 UAH per cubic meter for garbage [9].

However, this tariff includes only transportation and disposal of garbage at the landfill. Although the law of Ukraine "On Waste" includes 10 separate operations with waste: collection, transportation, sorting, storage, processing, processing, utilization, disposal, disposal and disposal.

Thus, the current tariff includes only two waste operations. Also in Ukraine, the tariff is not calculated depending on the type of waste. This can be explained by the fact that garbage sorting has not taken root in our country [9].

2.4 Waste management

2.4.1 Garbage sorting

One of the priority mechanisms in the hierarchy of waste management established by European directives is the introduction of separate collection of solid waste. The Ministry of Regional Development reports on an annual increase in the number of settlements in which this method is implemented: from 822 settlements in 2017 to 1,181 last year [8].

However, the percentage of population coverage in them is small - only 39.1%. And in general, in Ukraine there are about 30 thousand settlements, so that the method of separate collection of household waste in total is introduced only in 4% of settlements [8].

At the same time, the government expects that after 4 years at least 23% of the population should separately dispose of garbage [9].

Experts note that the benefits of colored containers - collecting recyclables for processing plants - are greatly exaggerated. Firstly, in fact, now all the garbage is sorted out: people with no fixed abode pull out all the useful things from the garbage bins that can be handed over at the nearest recycling center [10].

Table 2.1

Recyclable value by type of waste

Recyclable value by type	
waste paper	1 UAH per kg
polymers	3 UAH per kg
cullet	0.5 UAH per kg
tin	0.16 UAH per kg

Secondly, there is no guarantee that the issue of separate waste collection will be approached quite responsibly and containers will be filled strictly for their intended purpose. "Even in Germany, now a maximum of 35% of garbage is collected separately in different containers, everything else is dumped into a common" black "container," notes Andrei Grushchinsky.

According to him, organizing separate waste collection is now not beneficial for anyone: the prices of recyclable materials that our enterprises offer cannot cover the costs of purchasing garbage bins and arranging transportation, especially considering that even before they get to the sorting station, homeless people choose from there valuable components.

According to environmentalists, MSW on average can contain up to 40% of valuable materials. But, given that Ukraine still collects mainly waste in “general” containers, potential recyclables deteriorate and become contaminated, and the amount of valuable resources is reduced to 5-10% [10]. Composition of waste is presented on Fig. 2.6.

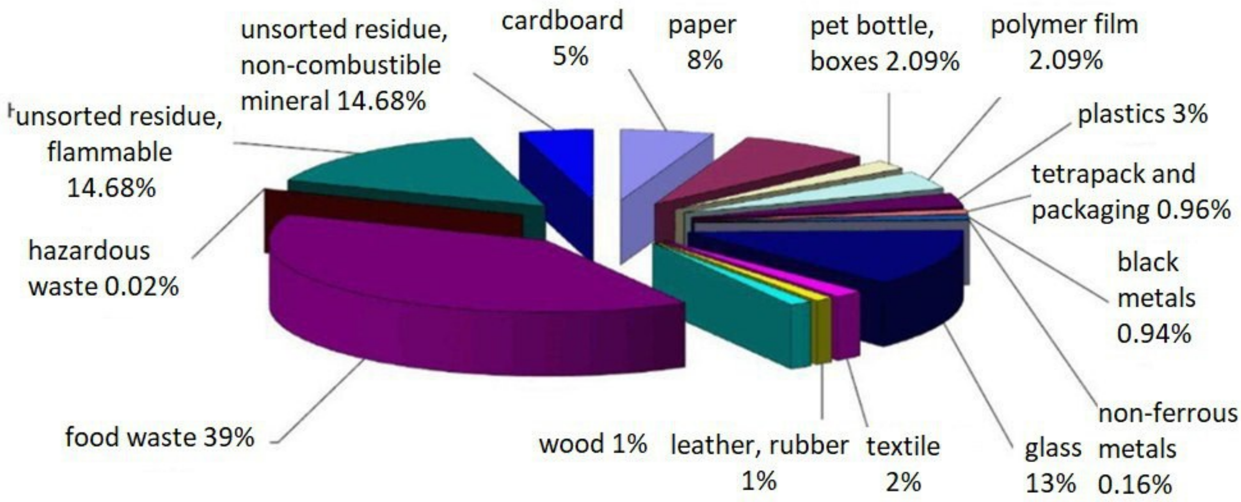


Fig. 2.6. Composition of Waste

In addition, even garbage collected separately will have to be sorted again at the enterprises (Fig. 2.7). “For example, there are different processing technologies for different types of plastic, so it is separated by type and color on the sorting lines. In addition, not all polymers are recyclable. Of the 1000 types of containers and liquid packaging, only 20-40,” explains Ukrainian Director production and environmental association for the procurement and use of secondary material resources "Ukrvtorma" Peter Semko.

	Waste paper	Polymers	PET bottle	Cullet
The number of enterprises engaged in the processing of secondary raw materials	17	39	19	16
Production capacity	1200 thousand t.	260 thousand t.	77 thousand t.	800 thousand t.
Power use	92%	65,4%	65%	60,2%
Congestion	1104,5 thousand t.	170 thousand t.	50 thousand t.	482 thousand t.

Fig. 2.7 Separate Waste Processing Facilities

As a result, it turns out that there are not enough domestic recyclable materials for the full-fledged operation of Ukrainian processing enterprises, therefore it is even bought abroad. So, last year the enterprises of the Ukrvtorma association purchased 202.2 thousand tons of waste paper in Russia (a total of 392.3 thousand tons were purchased), and 17.4 thousand tons of polymers in Poland (a total of 53.4 thousand tons were purchased), in Belarus - 24.1 thousand tons of cullet (total purchased 32.5 thousand tons) [10] (Fig. 2.8).

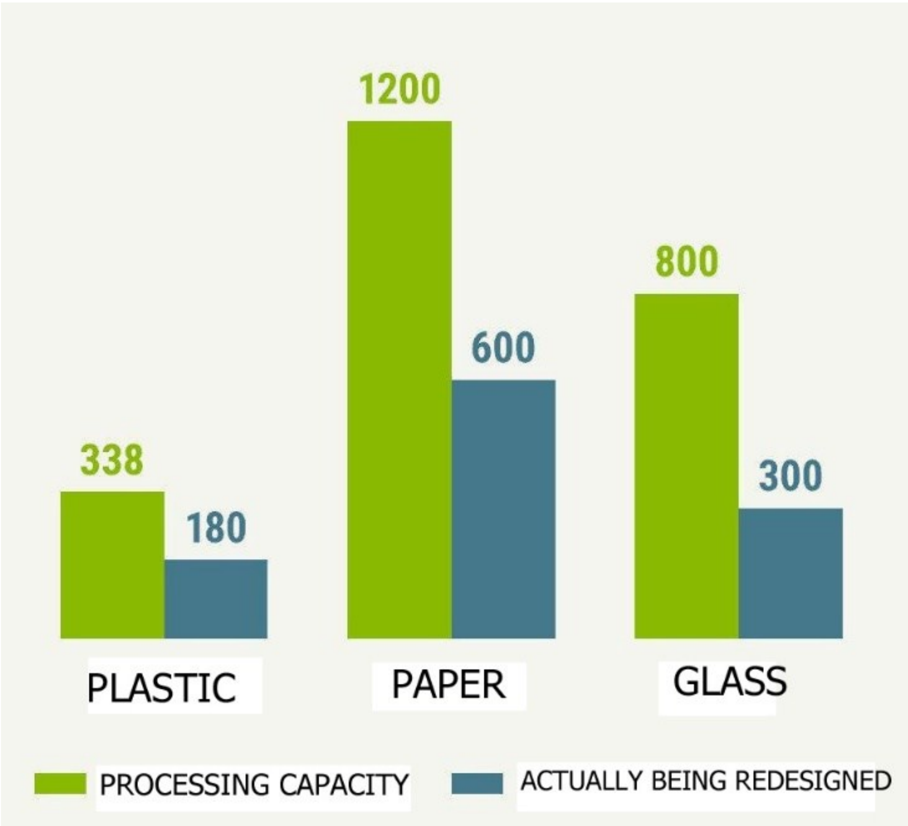


Fig. 2.8. Processing Capacity

"Due to the fact that neither the population nor the manufacturers pay for packaging processing, the organization of collecting and recycling costs much more for business than in Europe, where the cost of packaging processing is already included in the price of the product. Therefore, our secondary materials are at cost more expensive than imported and does not correspond to the prices that our processing enterprises give to it.

At the same time, if the price is raised for it, enterprises will not buy it, since the cost of imported recyclables for businesses will be more attractive. And if you lower it, but it will become unprofitable for the population to take it to recycling centers, "explains Sergey Volkov, head of the public environmental organization Druze Zhittya [10].

How much Ukrainians do pay for garbage collection is presented on Fig. 2.9.

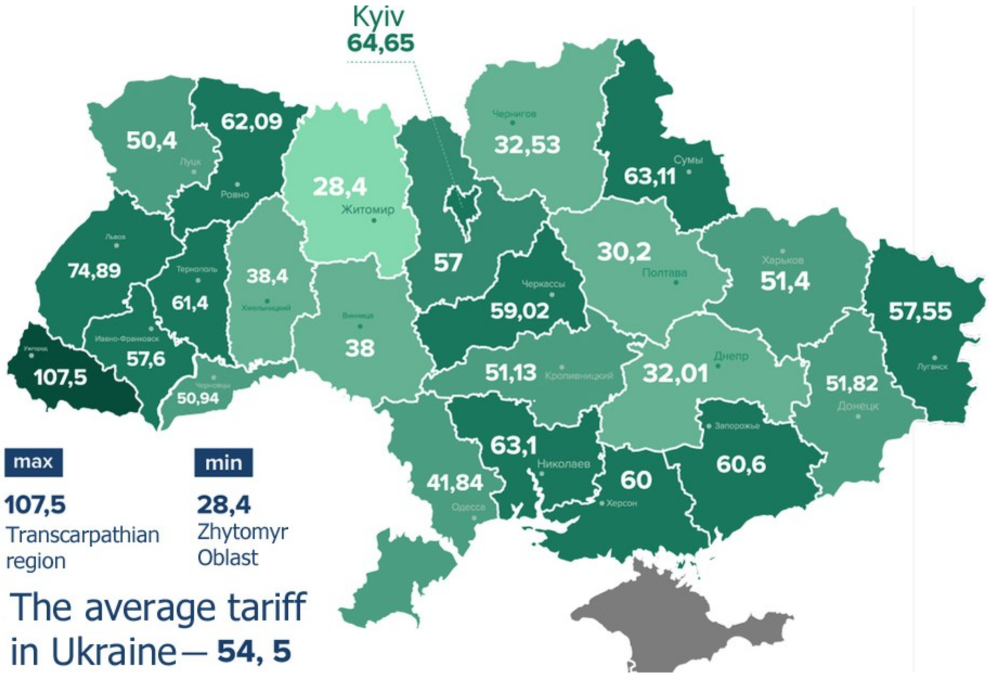


Fig. 2.9. Payment for Garbage Collection

In total, according to the AMCU, 1,146 companies were involved in garbage collection in Ukraine. Most of them are utilities. Private among them are 292 companies. Most of all, the share of private owners is in Kiev (83%) and Transcarpathian (58%) [11].

In addition to six thousand legal dumps, the country has over 35 thousand illegal dumps. Up to 11 million tons of waste are transported there per year. The total landfill area is almost 5% of the country. In Ukraine, there is only one incinerator - the Kiev enterprise "Energy". In general, we recycle only about 3% of household waste. The rest is exported outside the settlements and stored for decades.

It is significant that the National Waste Management Strategy adopted by the CMU intends to ensure the collection of dry waste up to 50% in the short term. And since 2018, the Law on Separate Garbage Collection has already been in force, obliging Ukrainians to sort garbage [10].

However, for a number of reasons, these laws do not work. Firstly, Ukrainian society is not accustomed to sorting garbage. Secondly, there are no control mechanisms for those who are fundamentally not going to separate the “dry” waste from the “wet” one.

Thirdly, many management companies are in no hurry to install separate containers for plastic, paper and metal in multi-store buildings.

The process will move when environmental thinking becomes equally relevant for government, citizens, public institutions, and business. In the matter of waste management, the responsibility of all parties is important.

So, Ukrainians should be responsible for the home sorting of garbage and its delivery to collection points. Municipalities provide waste collection and industrial logistics in the community. We are talking about the vital products of citizens, enterprises, restaurants, shops, and offices. The search for investments to create the necessary processing capacities is also part of the municipal responsibility.

The task of public institutions is to promote environmental thinking in communities. A simple example of a successful eco-project is a public campaign offering an alternative to disposable glasses in local coffee houses.

It is estimated that the provision of a discount on the format of "coffee in one's cup" is interesting to every fifth buyer. And this is minus 3 thousand disposable glasses thrown into the bins from one point every month. In Kiev, Lviv, Cherkassy dozens of coffee houses supported this initiative. I hope my native Kramatorsk will also join this initiative.

Business needs to be involved in the recycling of packaging and expired products, including tires, batteries, pharmaceuticals. After all, this is an incentive to develop products that are easier to process, containing less harmful substances.

An important element is the introduction of public-private partnership mechanisms. For small communities, inter-municipal cooperation is relevant. For example, in Latvia, local government forces create factories with up to 30 co-owners [11].

It's real to establish a European waste management system in Ukraine. It is difficult for us to expect significant financial support from the EU, which the Poles received. And it is unlikely that the Kiev factory "Energy" we will open a ski run, as in Copenhagen. But, the synergy of efforts, in the end, will teach us to convert rubble debris into Gcal, megawatts, tons of metal, plastic and other recovered resources.

2.4.2 The second life for garbage: how to fix the situation with garbage

The idea of separate collection of garbage in Ukraine has ripened for a long time and just as long ago they tried to implement it. But mainly these were local initiatives - for example, the opening of recycling points in large cities. At the legislative level, the norm for separate collection of garbage was fixed only this year. The sorting law prohibits the removal of waste to landfills. They need to be recycled and disposed of [11].

Garbage sorting is a very important step in this chain. The main idea is to reuse solid waste - for example, glass, plastic, cardboard. Organic waste must be disposed of - although it can also be recycled, composted or aerobically treated.

According to the Ministry of Ecology, since the beginning of the year, separate household waste collection points have been introduced in 575 settlements. Due to this, it was possible to recycle and dispose of about 5.76% of household waste. Of these, 2.72% were burned, another 3.04% of the waste was disposed of at recycling and recycling centers [11].

However, these figures are still quite small. For example, in the European Union up to 40% of all waste is sorted for recycling - almost 8 times more. One of the reasons for such a low indicator is the low level of public awareness of the importance of separate collection of garbage.

In order to draw attention to the problem, in Lviv an eco-project "Friend of Life" was organized by Carlsberg Ukraine. For two weeks, young art students from all over the country worked with solid waste, creating art objects to prove that garbage also has a second life.

“I took the shell as the basis of my object, because it has a sacred meaning - in many religions it means a second life,” said the author of one of the objects, Alena. Her sculpture is a shell made of metal cans and corrugated cardboard. “My shell it’s also connected with a new life, but with household waste. It also encourages people to take garbage sorting more responsibly. "

Students presented a wide variety of sculptures. There were decorations made of plastic bottles, a spider made of plastic pipes, a handmade of polyethylene, a stork made of black plastic - as a symbol of oil that pollutes water bodies. Participants say that while they were busy with their work, they thought about how much garbage they produce and where it goes. And they hope that this exhibition will also affect other people.

“Unfortunately, for a long time the issue of ecology in Ukraine has been given very little attention, since the priority has always been more acute and urgent problems of the economy. Now the government has introduced a waste management strategy, and very soon we will have the right European regulation., not only the government, but also business and society itself should help these laws work. After all, laws will never work if the society is not ready to become an executor of this decision, "the senior director said Corporate Affairs of the company Carlsberg Ukraine Poddubnaya Eugene Smirnov.

The head of the educational direction of the public organization "Ukraine without wastes” Olga Chernyavskaya notes that in general the situation with separate collection of garbage in Ukraine has improved. Although, of course, it’s too early to talk about a full-fledged breakthrough [11].

“We started three years ago and then the situation was completely different,” Chernyavskaya recalls. “We had almost no recycling points in Kiev, now there are more of them. And there are more people who thought about sorting out the garbage. "But now there is another problem - it is very difficult to separate the garbage separately when you go out into the yard and do not see a separate collection tank there."

In order to solve this problem as well, the Ministry of Ecology of Ukraine developed the National Strategy for Waste Management - it lists the principles of the waste hierarchy, and also laid the foundations for the expanded responsibility of producers and the use of the environmental tax for the disposal of household waste. According to Evgenia Poddubnoy-Smirnova, such a strategy will be able to change the situation with garbage in Ukraine. But without the desire of society, it will not work.

“I think we need to work with the younger generation,” says Elena Babykina, a leading specialist in corporate relations. “And gradually we will come to the conclusion that it’s right [to sort the garbage], and it’s not a shame to mess around with garbage. After all, it reaches the point of absurdity “Some waste-processing companies import garbage to load their capacities, while in Ukraine unsorted resource-valuable materials litter landfills!” [12].

Olga Chernyavskaya, the head of the educational direction of the public organization Ukraine Without Smile, names several simple rules for those who decide not only to sort the garbage, but also to reduce its quantity in general:

• refuse things that are used once (a paper cup of coffee, a plastic tube, a plastic bottle of water). To do this, you can ask to make coffee in your cup, get one bottle that you constantly use;

• abandon the thoughtless purchase of things. For example, do not buy an extra T-shirt if it is not urgently needed;

• abandon plastic bags in favor of food bags;

• Separately sort solid waste and organic;

• Find a recycling center in your city.

2.4.3 Waste for power production

Once all the valuable that can be recycled is taken from solid household waste, the garbage can be sent for recycling with energy production. This can be done in three ways: to collect biogas directly at the landfill; to produce biogas and solid fuel in plants with a mechanical-biological method of processing solid waste; to produce electricity and heat by direct burning of solid waste in factories with a thermal processing method [12].

Moreover, in the case of electricity production from biogas and biomass, it can be sold at the "green" tariff - 0.1239 euros / kWh without VAT [12].

The Ministry of Regional Development, Construction and Housing and Communal Services informs: "After the adoption of the Law of Ukraine" On Amending Certain Laws of Ukraine on Ensuring Competitive Conditions for the Production of Electricity from Alternative Energy Sources "in 2015, in which sections were introduced to increase the" green "tariff for electricity from biomass and biogas from household waste and the abolition of requirements for the local component, in Ukraine there is a tendency to increase the number of landfills, by arranged biogas extraction system and installed cogeneration plants to produce thermal or electric energy.

So, at 32 landfills, a biogas extraction system is arranged and cogeneration units with a capacity of 19 MW are operated. The amount of electricity generated in 2018 is more than 63.3 million kWh. "

Enterprises with a mechanical-biological method of processing solid waste also have the opportunity to sell electricity at the "green" tariff. There are no such in Ukraine yet, however, plans were reported to build factories in Lviv, Zhytomyr, Poltava, Khmelnitsky and Kiev [12]. Production of electricity is shown on Fig. 2.10.

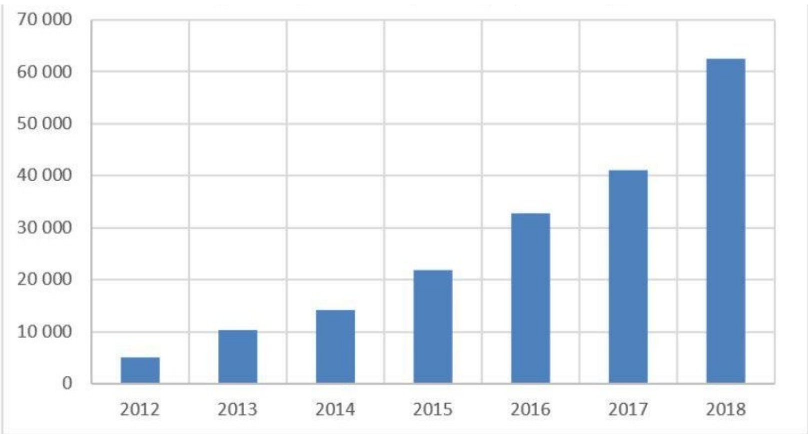


Fig. 2.10 Production of electricity, MW*h

In particular, in the capital, the plant should replace the MSW Landfill No. 5 and recycle at least 450 thousand tons per year: as much as the landfill in the village of Podgortsy near Kiev took on every year. "Kyivspectrans" decided that it will take part in the construction of a plant using mechanical and biological technology. This technology is fundamentally different from incineration and stipulates that solid waste that is selected separately from solid waste, both manual and automatic, are resource-valued, that is, recyclable.

Organic matter is separated from the remaining mass and sent for forced processing at an anaerobic plant, where biogas is produced in 21 days, from which electricity is generated. After that, technical compost remains, which can be used in other industries, for example, in agriculture [12].

In turn, the inorganic is divided into what burns (is utilized during burning) and what does not burn (goes to landfills and is inert to the environment), "explains Andrey Grushchinsky, how the future enterprise works.

According to a study by the Bioenergy Association of Ukraine, a plant with mechanical-biological technology will be able to earn 29.7 euros per ton of processed solid waste at the green tariff. However, taking into account the specific capital costs of such projects (150 - 400 euro / t solid waste), only the cost of processing will be 30-80 euro / t solid waste [12].

At the same time, investors are not deceived even with the “green” tariff: under current legislation, the level of such a tariff will gradually decrease by 10% in 2020 and 2025, and in 2030 it will cease to operate for producers of electricity from biogas and biomass [12].

At the same time, incinerators with the thermal method of processing green solid waste do not apply to the tariff. Now in Ukraine there is only one such enterprise - the metropolitan plant "Energy", which processes 280 thousand tons of MSW per year and provides heating for about 300 houses of the Poznyaki housing estate.

According to official data, today only 3% of waste is incinerated in Ukraine, and the National Strategy regulates that this value should not exceed 10%. Investors are hesitant to launch new waste incineration plants: its construction in compliance with all environmental standards will cost 130-270 million euros depending on capacity, while the cost of processing a ton of solid waste at such a plant will be 90-130 euros [12] .

Despite the fact that recycling points are included in the current tariffs for MSW management services, garbage after surface sorting is nevertheless sent to thousands of years of landfill - this is cheaper. For example, Kiev "Energy" takes 143.5 hryvnias for burning a ton of MSW, while the burial rate is on average from 50 to 110 [12, 13].

“Under current legislation and political will, the sphere of garbage processing will not be able to develop normally. In the end, all the questions come down to one thing -

who will pay for it? Now people don't understand how much they spend on garbage collection. If you raise tariffs for waste management services "It should be painful for the population. People will begin to monitor how much, what and how they throw away. In the same way, when people started saving on light and water," said Sergey Volkov [13].

They haven't been able to find the extreme ones for several years already: in the parliament, about a dozen bills that offer different schemes for financing the sphere of processing municipal solid waste are dead weight in the parliament. Firstly, it is already possible to raise tariffs for the population. Potential revenue (Fig. 2.11).

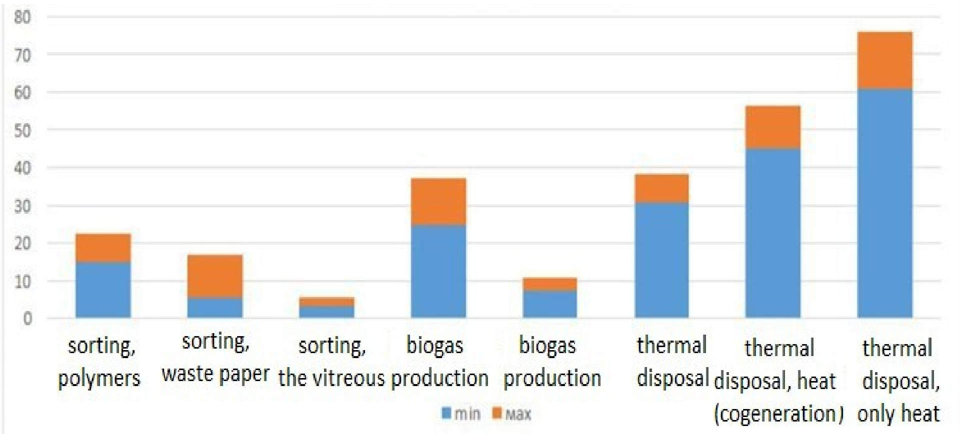


Fig. 2.11. MSW Potential Revenue, euro/tonne

"On average, a payment for processing can grow by 100 hryvnias. But local governments will not make such a sharp increase. In addition, this is not entirely fair, since it will not work to calculate the amount of garbage produced. Someone who produces a minimum of waste per month, must pay the same amount as the person who produces a lot of garbage. Yes, in the current version of the law "On Housing and Communal Services" there is a norm establishing that, in the case of separate collection of waste, from the payment for the service for household waste excluded the cost of operations for the processing of sorted waste, but how this mechanism to realize how to control who, what and how to throw, the legislator is silent ", - Gruschinsky explains Andrew [12].

According to him, it is possible to get out of such a delicate situation by setting an environmental tax on containers and packaging, as proposed by bill No. 4835-d. At the same time, the price of consumer goods will increase slightly - by 10-15 kopecks - and will not be so painfully perceived by Ukrainians as a sharp increase in the utility tariff [13].

However, manufacturers and importers of containers and packaging are not happy with this idea: the environmental tax will go to the special budget account, and how it will be distributed thereafter - the construction of a waste recycling complex or someone else's pocket - is unknown. However, there is an alternative to this proposal: the principle of expanded responsibility of packaging and packaging manufacturers, in which they themselves must unite in a non-profit organization and address the issue of packaging collection and processing.

But in the existing version of bill № 6602, this norm, according to experts, also does not bring an optimal solution. "This legislative initiative" will complicate the procedure for the creation and functioning of organizations of extended producer responsibility due to inconsistencies in the legal regulation of their status and activities, as well as the requirement to pay a bank guarantee as a prerequisite for making these organizations in the relevant register and performing their functions," states his open letter to the European Business Association [13].

However, other ideas regarding the modernization of the waste management sphere are swarming under the parliamentary dome: they propose increasing the tariff for the disposal of solid waste, so that it would be more profitable for consumers to send them for recycling; create a deposit system for the disposal of containers and packaging, in which consumers could return them to certain points and receive a deposit back.

Bill № 4835-d proposes, among other things, to establish a "green" tariff for burning sorted waste, from which all useful components have been removed. But the community of environmentalists was strongly opposed to this approach: with this concept, the volume of waste generated will not decrease, and it will only be beneficial for plants to accept large batches of solid waste for processing into expensive electricity.

However, no matter how much disagreement arises on the basis of the “garbage problem”, all parties agree on one thing: it must be resolved, but with maximum economic benefit and minimal damage to the environment.

“The start of the construction of new waste recycling plants and attracting investments in this area will allow us to achieve a replacement of 1 billion M^3 of gas equivalent per year and will help solve the country's energy problem and increase its energy independence,” the main argument in the State Agency for Energy Efficiency and Energy Saving of Ukraine cites.

In Ukraine, it is necessary to turn energy waste disposal into a cost-effective project for investors. This was discussed at a meeting chaired by the head of the State Agency for Energy Efficiency and Energy Saving Sergey Savchuk with representatives of the Kiev City State Administration (KSCA), the National Commission for State Regulation in the Sphere of Energy and Utilities (NKREKU), business and experts [13].

According to the press service of the Cabinet of Ministers, the key topic of the meeting was the introduction of legislative changes to stimulate energy waste management in Ukraine, developed by the State Energy Efficiency.

In addition, the UK plans to install one of the largest energy waste recycling plants in Europe with a capacity of 60 MW. The plant will process about 600 thousand tons of garbage per year and generate electricity, which will be enough for about 110 thousand households [13].

Based on the concept already developed by the State Energy Efficiency, Kyiv City State Administration and NKREKU, the meeting participants propose the following legislative changes in key areas:

• establish a clear administration system at the municipal level:

• create an institution of a “single operator” for household waste management;

• introduce the possibility of concluding long-term agreements on waste processing;

• provide guarantees to waste processing enterprises for the workload of plants with the necessary amount of resources.

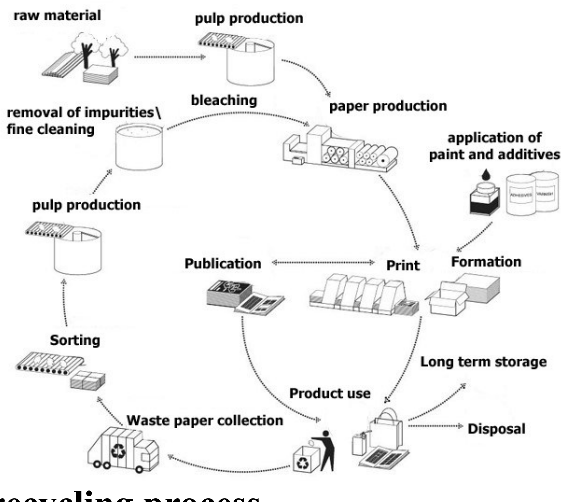
• Provide for the use of RDF / SRF as a potential energy source. At the same time, it is important to ensure environmental safety and establish clear tariff rules for energy waste disposal services (gate fees).

• introduce incentives for waste processing instead of their disposal at landfills or landfills. Today there is no such motivation, and the cost of landfill is much lower than the cost of its processing.

• introduce effective control and responsibility in this area.

2.4.4 Gross collection

Collecting MSW without dividing it into individual components is called gross collection. The planned and regular organization of the collection and disposal of MSW provides for the removal of household waste at a fixed frequency. The frequency of disposal of MSW is established by sanitary services, based on local conditions in accordance with the current rules for the maintenance of territories of settlements. The type and capacity of the garbage cans used depends on the amount of waste being collected, the type and surface of the building, the method of loading and unloading of the MSW. In a low-rise building, all MSW is collected in the garbage cans. Then it is manually or mechanically loaded into the dump truck. For multi-store buildings or groups of low-rise buildings, a standard container is mounted on castors, which is discharged from the waste in a mechanized way into a garbage truck. In places of large accumulation of MSW install removable body-container. In the low-rise building, 70 dm^3, 110 - 120 dm^3 and 210 - 220 dm^3 tanks are used for the gross collection of MSW [14]. In the individual building smaller tanks are used, for example, 35 dm^3. Before the arrival of the garbage truck, the tanks are exposed by the population to the roadway. Tanks are made of sheet steel, aluminum, plastics. Preferred are plastic tanks. The mass and cost of such tanks is relatively low, the service life is 2 - 3 times more steel and is 5 - 6 years. Plastic tanks are easy to operate, have a good appearance [14]. Wet waste does not stick or freeze to their walls, which facilitates their washing and disinfection. When using plastic collectors, it is necessary to follow fire prevention measures. In some countries, disposable paper, cardboard or plastic collections are used, which eliminates the overloading operation and minimizes contact between service personnel and waste. The capacity of disposable collectors ranges from 70 to 200 dm3. Such collections are installed on special containers of the specified sizes corresponding to the loading device of the garbage trucks. In high-rise buildings, garbage cans of various designs are arranged. Usually they consist of a vertical barrel, taps with receiving devices, cameras for collecting solid waste and a ventilation duct. Garbage trunk is a pipe with a diameter of 400 - 600 mm, made of asbestos cement, concrete or steel with a smooth inner surface [14]. Steel pipes must have a vibration absorbing coating on the inner surface. The intake valves must prevent the entry of gases from the garbage line when closed and provide noise protection. The entrance to a waste bin, usually in the basement or on the ground floor, is insulated from the entrance to the dwelling. The valves are made of sheet steel covered with anti-corrosion paint. The camera is equipped with water and sewerage. Audit openings for cleaning, disinfection and deodorization of the trunk of the trash can usually be arranged at the top of it. In recent years, other methods of MSW disposal have been developed. For large-panel multi-store buildings, block designs are included that include trash can elements. In some cases, a system is used in which the MSW is delivered to the hoisting devices on trucks by trolleys, which feed them to the garbage trucks. Such waste disposal systems are created in medical institutions, hotels, hostels. Separate collection. A separate, or selective, collection system for individual MSW components ensures that relatively clean secondary resources are received from the public and that the amount of waste being disposed of is reduced. This system demands from the population a conscious approach to the disposal of solid waste, an increase in the number of service personnel, containers, special transport for the export of each type of recyclable material. These additional costs are fully offset by the recycling of secondary resources. In Ukraine, the selective collection of MSW has not yet received practical development. In the United States, the selection of recycled MSW fractions (waste paper, textiles, plastics, bottles, etc.) is done through special programs funded and developed by individual states. The practice of separate MSW collection is developing in several European countries. Usually, these technologies are based on the principle of collecting MSW in separate containers (bags or containers) for different types of waste. These containers are located both at home and in the entrances or near the houses. There are various modifications to this technology [15]. For example, in Germany the experience of collecting MSW in two types of trays - green (waste paper, metal, glass, polymers, fabrics) and gray (other waste) with their export for processing has been accumulated. In recent years, a separate collection of MSW has been performed in Germany for five or more species. One variant of selective collection technology involves the organization of mobile installations involving several types of containers. The movement of installations is carried out on schedule, and the population is supplied with packages for individual components of MSW. In this case, economic incentives are provided for delivered types of recyclables. Collection and disposal of bulky waste. Oversized items do not fit into standard containers in size [14].



2.5 Waste paper recycling process

After using the paper, it must be collected and sorted into different categories depending on the type. Waste paper processing technology depends on the material being processed and the final product. Usually at the stage of collection and sorting, craft paper, corrugated cardboard and packaging cardboard are separated from graphics paper [15].

Fig. 2.12. Waste Paper Recycling Stages

Waste paper processing technologies differ depending on the raw materials used and the target products. Nevertheless, in each process, it is possible to distinguish the main stages that lead to the production of the secondary fiber used in wet processes in the manufacture of paper, sanitary products, cardboard and corrugated board. According to this technology, 80-90% of all waste paper in Ukraine is processed [15].

Waste paper recycling for wet processes generally includes 5 stages: dissolving waste paper, cleaning the waste paper from impurities, thermomechanical processing, disassembling the waste paper, fine cleaning the waste paper (Fig. 2.12).

Depending on the type of waste paper, part of these operations can be excluded from the process.

Recycling of waste paper has become an excellent alternative to the excessive use of cellulose. She solved the following problems:

- minimized deforestation;
- solved the issue of high toxicity of already used paper;
- Reduced environmental pollution by waste products.

Today, in every country there are many factories and plants that provide waste paper recycling services. Having sorted the garbage, you can turn in the waste paper to the collection point [16].

Mass separation. The main task of this stage is to separate the impurities from the bulk. The main problem is adhesive substances - scotch tape, sticky edge of stickers, electrical tape, book spine and newspapers. Unfortunately, the chemical process of separating such sticky substances has not yet been invented. Pass through a large sieve, they clog equipment and create damage. To do this, all paper is passed through a fine sieve, which increases time consumption. After the mass enters the mechanism, with the help of friction and turbulent pulsation, the paper is divided into fibers. Part of the paper that has passed through the sieve is sent to a further processing niche. Residues - roots, paper clips, scotch tape sent to the waste department. The concentration of waste paper is set automatically by the mechanism; the density indicator can reach up to 5%. To ensure the highest quality cleaning, sets the density to not more than 0.5% [16].

Paper waste sorting.

• Group A. Contains the highest quality and clean waste paper. This group includes - uncontaminated white paper intended for printing, the remains of unbleached sulfate pulp, waste from the manufacture of first-class paper. Also included are packaging bags that are not contaminated with waterproof materials.

• Group B. This includes used cardboard, corrugated paper, or its residues when cutting. In addition - used notebooks, receipts, notebooks, brochures. All white paper should not contain hardcover.

• Group B. This includes low-quality products. It can be paper production materials - sleeve spools. Also - used newspapers, production cardboard. All materials may contain extraneous chemicals in the form of a waterproof layer.

Machine sorting paper. After separation into grades, the mass is machine sorted. It is a division by:

- Color is the most common principle. The sensor located in the production machine recognizes the color, and according to this groups the mass;
- Humidity - this variety requires its own specific approach and certain processing;
- Paper length - this grade requires more voluminous sorting cells;
- Contamination - this category requires additional cleaning.

Having distributed the entire mass into categories, the machine proceeds to further processing.

▪ Dissolution of waste paper into fibers. The dissolution of waste paper into fibers is carried out in an aqueous medium in pulpers. Water is poured into the pulper and waste paper is laid. Rotational motion of the rotor forms turbulent flows, which create intense abrasive forces between the individual fibers. In pulpers, coarse and light inclusions are also separated.

After the pulper, the pulp contains both fibers and non-bloomed pieces of waste paper. The finished suspension of waste paper passes through the openings of the sieve and enters the next operation.

▪ Cleaning of waste material from impurities. At the second stage, the pulp mass is cleaned of heavy and light impurities. Cleaning from heavy impurities - sand, glass, paper clips, etc. - is carried out in waste paper cleaners, which are a cyclone. Heavy impurities are deposited in the dirt collector and periodically removed. Light impurities in the form of polymer films and waste paper pieces are removed by vibratory sorting with a slotted hole. The past sieve of the waste paper is sent for further regrouping. To reduce waste paper waste, water is supplied to all types of treatment equipment.

▪ Thermomechanical processing. The stage of thermomechanical processing is provided for in the technological process, if cardboard and paper having a complex composition are used as feedstock. Examples of inclusions include bitumen, wax, paraffin, glue and other substances. These substances pollute the paper and paperboard equipment. Thermomechanical treatment neutralizes their effect due to dispersion to sizes at which substances do not adversely affect the production process [16].

There are two types of thermomechanical processing:

• cold method - dispersion is carried out at atmospheric pressure and temperature up to 95 ° C;

• hot method - dispersion at elevated pressure (up to 0.3-0.5 MPa) and a temperature of 130-150 ° C.

▪ Disposal of waste paper. The cleaned pulp mass containing both plant fibers and fiber bundles and small pieces of waste paper goes through the stage of self-discharge in conical or disk mills (enthippers). The stator and rotor of the mill are equipped with a special grinding set, the gap between which is 0.5-2 mm. As a result of turbulent pulsations and mass friction inside the stream, the pieces of waste paper and mass beams are separated into individual fibers. The loose material goes to sorting’s that weed out unfibered bundles of fibers and impurities.

- Thin cleaning. For the final cleaning of the waste paper as from nodules and small dotted inclusions, vortex conical cleaners are widely used, which, as a rule, are installed in three stages.

Wet waste paper processing technology is characterized by high energy intensity of production and high specific consumption of water (up to several tens of cubic meters per ton of production), as well as a large volume of wastewater [16].

Additional treatments. In some cases, it is necessary to resort to thermomechanical treatment after which such substances as glue, bitumen, wax, paraffin is split. These substances can form part of paperboard and paper of some types and severely pollute the equipment. Thermomechanical processing can be performed by cold and hot methods under different pressures. Also, in some cases, bleaching with chemicals is used to obtain white office paper. Thus, paper products gain a second life and bring great benefits to nature and man. The need for them is constantly increasing in the process of economic activity, therefore, processing volumes are growing, and technologies are being improved and will never remain unclaimed [17].

Alternative processing methods. In addition to traditional processing into paper and cardboard from waste paper, the following materials are made:

- organic heaters (Eco wool);
- roofing materials;
- insulation materials;
- disposable flower pots;
- packaging for eggs;
- toilet paper;
- paper napkins;
- disposable tableware;
- fabric for clothes.

The primary stage of processing, which includes obtaining and purifying the pulp, is the same for all these technologies.

Attempts are being made to dryly break the bonds between cellulose fibers, but so far they are far from commercial applications.

Finishing materials from pressed cellulose fibers are similar in their characteristics to the popular fiberboard sheets, but they are cheaper.

Eco wool made from recycled paper is not much inferior in its characteristics to basalt and glass wool, is harmless and recyclable.

Shock-absorbing fillers pressed from cardboard are very popular, which are in no way inferior to polystyrene foam, but much cheaper. Their production does not require sophisticated equipment, and the machine for the manufacture of such chips does not take up much space [17].

Industry outlook. The recycling of waste paper into various materials is very in demand, so the industry is constantly evolving.

Decreasing forest volumes and reducing the availability of unprocessed wood pulp is the reason for the rapid growth of the entire industry. In addition, the recycling of waste paper allows you to save trees that would need to be cut for paper production [16].

Despite the need for large investments, the recycling of waste paper is a very profitable business, because the raw materials are very cheap, and paper and cardboard are in demand. The low price allows you to effectively compete with paper from wood, because there are no costs for deforestation, log shipping, storage and processing into wood chips.

The profit of the enterprise is affected by access to the following resources:

• cheap electricity;

• cheap water;

• cheap discharge of waste water;

• low-cost landfill for waste and waste storage.

Paper recycling is a very profitable business that is constantly evolving. New technologies are emerging that improve the process and increase the number of waste paper recycling cycles. New materials are emerging for which recycled cellulose is required [17].

The industry is developing successfully, covering large and small cities, because the demand for paper products is only increasing, and the feedstock is very cheap.

Indeed, many are still throwing newspapers and magazines into a bucket, and they can get a small, but payment, for waste paper.

In the near future, new technologies will appear that will significantly increase the number of waste paper processing cycles, which will reduce the number of trees cut down and improve the environment.

The introduction of separate garbage collection in the near future will significantly increase the amount of paper and cardboard waste to be recycled.

This will ensure an increase in the amount of raw materials supplied, which means it will increase the output of finished paper. The development of technology will increase the number of paper processing cycles, because even very short fibers can be used if you mix primary cellulose with them [17].

2.6 Recycling Plastic Waste

The production of plastic products is increasing year by year. These are bottles, cans, cans, trays, pallets, packages, packaging, labels, film, adhesive tape, partitions, various ceilings, signs, signs, light boxes, nets, gratings, folders, artificial grass coverings, filter tubes and many other products.

The amount of plastic waste is increasing, which not only litter the environment, but also pollute it. Plastic belongs to materials that practically do not decompose over time, and when burned extremely toxic substances are released that cannot be removed from the body. Therefore, plastic products must be recycled [18].

Plastic processing consists of several stages:

• collection;

• sorting (by color, by quality, clean / dirty waste);

• pressing;

• processing itself (cutting, washing, drying, production of regranulate);

• production of new products.

There are several ways to recycle plastic.

- Pyrolysis - thermal decomposition of substances in the presence of oxygen or without it.
- Hydrolysis occurs under extreme temperatures and pressures. This method of using wastes is energetically more profitable than pyrolysis, since high-quality chemical products are returned to circulation.
- Glycolysis - destruction occurs at high temperatures and pressure in the presence of ethylene glycol and a catalyst to obtain a pure product. This method is more economical compared to hydrolysis.
- Nevertheless, the most common thermal method of plastic processing is methanolysis - the splitting of waste using methanol.
- Currently, the most acceptable recycling method for Russia remains mechanical recycling - recycling (the method does not require expensive special equipment and can be implemented anywhere in the accumulation of waste).

Consider the stages of the recycling of PET bottles:

- The first stage: collecting and sorting bottles. Actually, there is nothing complicated, in more detail we will consider this issue a little later. We only note that at this stage of preparation we must establish an uninterrupted supply of raw materials and their further sorting;
- The second stage: crushing. For this stage, you will need a special crushing plant. Sorted bottles are placed in it, crushing takes place and flakes are obtained at the output, the size of which can be from 0.8 to 1.2 centimeters (depending on the size of the grill in the installation). Actually, this is pet flex. Then the crushed mass is thoroughly washed with caustic soda. After that, it is placed in a centrifuge that separates pieces of paper labels from the bulk in the form of sludge. Labels made of polypropylene, ringlet and cap are removed by flotation. Then the flex is washed again, this time with ordinary clean water, and placed in a tube dryer, in which drying will occur under the influence of a

stream of hot air. The final stage is the unloading and packaging of flex. In this form, the material can already be sold, but you can resort to a slightly different technology;

- The third stage of technology: agglomeration. The process procedure is extremely simple: the crushed mass is exposed to high temperature, as a result of which it is simply sintered and turns into small lumps. These lumps (agglomerate) can also be sold as raw materials, or can be "improved", that is, granulated;
- The fourth stage: granulation. Granulation is the further processing of the material. It will significantly increase the purity and quality of raw materials, which will positively affect its cost. The granulation process is also called briquetting, and its essence is to turn the crushed mass into pieces of the correct form, peculiar granules, the same in weight and size. This happens as follows: under slight pressure, the particles become denser, since there are voids between them. Then the particles themselves are deformed, they adhere at the molecular level. At the end of the procedure, the pressure rises, turning the elastic modification into plastic. The result is solid, uniform granules [18].

Plastic Bottle Processing Equipment. Recycling PET-tar involves the presence of certain plants designed for a complete processing process, which includes:

- agglomerate;
- granulation line;
- rotary chopper.

This kit is able to provide only basic processing, for a more complete processing process you will need the following equipment:

- a bath for soaking flask, as well as a container for cleaning it from detergents;
- dispenser;
- dynamic centrifuge;
- friction screw, etc.

The use of recycled plastic. About a third of recycled plastic is used to make fiber for carpets, synthetic yarns, and clothing. The remaining areas include the production of sheet, film, bandage tape, car upholstery [19].

About 70% of all recycled European PET is used to produce polyester fibers. Large fibers are used as insulation for sportswear, sleeping bags, as a filler for soft toys [20].

Recycled plastic is also used to make smaller fibers. They produce artificial wool used for knitted shirts, sweaters and scarves. Such fabrics may contain up to 100% recycled material. For example, an average of 25 recycled PET bottles is required to make a warm faux wool sweater [19, 20].

Sheet and ribbon are “classic” recycled plastic products. The sheet is made for the manufacture of plastic boxes (for fruits and eggs), which make up approximately 9% of the total use of recycled plastic. Other uses for recycled plastic include packaging for toiletries and consumer goods, bristles and nap, which, in turn, are used to make household brushes, brooms, and brushes (both conventional and for road cleaning equipment). As for the pads for the manufacture of household brushes, brushes, brooms, plastic waste is also used here.

This is thought to “close the recycle loop” because it allows the packaging to be recycled into a new packaging. All recycled packaging remains recyclable. Recycled plastic bandage tape is primarily intended for industrial use. It can successfully compete with polypropylene and steel tapes. Fibrous material obtained from recycled plastic can be used as a sorbent at a sewage treatment plant, as a heater or filler [20].

Recycled plastic is used in household goods, building materials, art objects. From plastic waste and mineral fillers (ash, sand), polymer concrete is produced, a very strong and durable material that has a variety of uses. Plastic made from used beverage bottles can be a potentially cheap raw material, and recycling it into polymer concrete will also solve recycling problems. The use of polymer concrete for repairing concrete from Portland cement can be very effective. The surface layer of polymer concrete can have a thickness of only 10 - 25 mm, which ensures wear, acid resistance and low permeability [21].

Polymer concrete is lightweight, quickly hardens and forms a strong adhesion to the concrete surface, it can be quickly applied and restored, which is very important for bridges and floors in industrial premises. The application of coatings from polymer concrete to reinforced concrete building structures significantly improves their appearance. The use of polymer concrete for the drainage of acid effluents, underground vaults, connecting boxes of sewer pipes is very effective.

Do not forget that the bulk of bedding fillers coming from China are made from recycled PET [22].

2.7 Recycling Glass Waste

Handing over glass breaks, glass containers and other products from this material to collection points for subsequent processing should be for fairly good reasons, which are listed below:

- This material practically does not decompose during burial. Products from it can lie in the ground for hundreds of years in its original form. Only after millennia will they be subject to complete biological and chemical decomposition. Therefore, without the collection and processing of glass, it is impossible to imagine the ecological safety of the planet, since in a short time it will all be dotted with products from this material. In addition, the glass is fragile and its fight poses a danger to humans, animals and plants [23].
- Glass recyclables can significantly save natural resources. If you use only 10% of the battle in the production of new products, you can reduce the consumption of natural gas by 3%. Well, if we transfer the production technology of such products completely to the use of glass breakage, then the gas savings will be 30%. Is it not true that this is an excellent indicator that will significantly reduce the cost of the final product [24].
- The secondary use of glass allows you to save vast areas of land, which, otherwise, should turn into environmentally hazardous landfills of non-recycled waste. In addition, the delivery of glass battle and products from this material to specialized

reception centers brings people a small but stable income. Additional banknotes are unlikely to be superfluous to anyone.

- When processing assembled glass, you can save not only on natural gas, but also on materials such as limestone mixtures, soda ash and sand, which are used in glass production. Glass products are a completely recyclable material, so its secondary use is a completely waste-free process, which significantly reduces the negative impact on the environment around us [25].

Thus, the disposal and recycling of glass waste is necessary to ensure environmental safety, preserve natural resources and reduce the cost of production of glass products.

Types of containers to be collected. The original glass recyclables can be various containers, products and battle. Basically, these are cans and bottles, which are accepted at collection points for glass containers.

Recently, the secondary use of such containers has come to naught, and mainly it is being processed.

Glass waste is divided into different classes depending on color: colorless (BS), brown (CS), green (ZS), etc.

Depending on the color, the glass battle is sorted before further processing.

Glass products are produced on the basis of the same substances: quartz sand, soda and calcium carbonate.

You should know that many types of glass are made using special additives and impurities. Such material is subject to processing in rare cases, so broken glass is mainly used [26].

Stages of processing raw materials. Glass battle is processed into ready-to-use material by the method of remelting in special furnaces.

The disposal process takes place in several stages, which are described below.

- At the first stage, there is a paid collection of glass waste from the population, enterprises and organizations. For this, special reception points are organized and agreements are concluded with large enterprises where glass waste is part of the technological process. In this process, urban landfills play an important role, on which large masses of such waste are generated.

- In the future, at the processing plant, the collected glass waste is subjected to primary washing and sorting into classes. Sorting is the most time-consuming job, as it is done manually on a moving conveyor. After separation by color, the glass break is subjected to grinding in crushing units and sieving with sorting into fractions.
- At the last stage, the prepared raw materials are melted in special melting furnaces, where at high temperature the waste turns into a homogeneous glass mass of a certain color. From this mass, new glass products are formed. Products can be made both completely from glass, and with the addition of a certain amount of the starting components: quartz sand, lime and soda.

Of course, this is a brief overview of glass processing technology without many details, everything is much more complicated.

Most often, primary processing for obtaining raw materials is carried out at individual enterprises and deliver the resulting product to manufacturers of various glass products [26].

And the melting process itself has its own nuances, but in general everything looks as described above. We will consider each of the stages of glass processing, starting with sorting, in a more expanded form.

Sorting, washing and drying. This operation begins at collection points of glass containers, where bottles and cans are separated by color.

Directly at processing plants, sorting is carried out on a conveyor using manual labor or special automatic separators.

For small enterprises, manual labor is mainly used, while large processing plants use automatic equipment, such as photo separators and other systems for splitting glass battle.

After separation of the glass by color, the waste is washed, various inclusions are separated and dried with hot air.

The quality of the final product depends on the degree of purification of the feedstock; therefore, cleaning and separation of glass battle is a very important operation in the entire technological chain.

It is carried out in several rotating containers, interconnected by conveyors. The equipment is equipped with various traps, magnetic separators, filters and gratings. At the final stage, the raw materials are dried in drying chambers [27].

Crushing and remelting. After cleaning the glass waste, it must be crushed to specific fractions, depending on the manufacturing process of the final product. Crushing of raw materials is performed on special automatic lines. Such equipment works as follows.

The prepared glass wastes are loaded into hammer crushers, where suspended hammers crush the raw materials to the required size and enter the discharge chamber through a calibration sieve. At the same time, the cleaning cyclone removes glass dust from the feed.

The glass raw materials obtained after crushing are ready for use. It only needs to be washed with a special solution, dried, add the necessary additives and packaged or sent to the furnace for re-melting [27].

Packed raw materials are sent for processing. If the company has a full cycle of obtaining finished products from glass waste, then either smelting or another technological operation is necessary.

Raw materials are smelted in special gas furnaces. Liquid glass masses can come in forms or on special blowing lines to obtain finished products. It all depends on the type of products that are needed from the waste glass.

Foam-glass blocks <are formed from foamed hot glass mass in molds of a certain size, and bottles and cans are blown out on automatic machines, also in special metal molds [28].

Some types of glass containers can be used a second time, without remelting the battle in the furnaces and making new products. These include standard bottles and cans, which after washing and disinfection are sold to the consumer, which brings a good income.

The main advantages of such processing are:

- Saving energy needed for production. Every 10% of used waste from the total mass of raw materials reduces energy consumption by 2-3% [27].
- The absence of non-recyclable waste: glass is a 100% reusable material, and the recycling process is a completely closed cycle.
- Reduction of harmful emissions from production. According to statistics, sulfur dioxide emissions fall by 10 percent, nitrogen oxides by 4%, and the number of micro particles decreases by 8% [27].
- Save space on landfills for waste. Every year, tens of thousands of tons of whole and broken glass products are sent to specially designated land plots for further secondary use in the future. Timely redistribution cycle saves space and money for the maintenance of such land.

Glass recycling uses only high-tech equipment, because the products that will be manufactured using it require glass that has high quality and the necessary chemical-mechanical characteristics [28].

Cullet Products. In addition to containers, it is possible to make inexpensive and popular products from glass waste, especially for the construction industry.

Glass combat is used in the production of many building materials, but the following items are the most popular of them:

- Glass wool. Universal insulation with high soundproofing properties. For its production, glass waste is remelted into a special fiber, which is the basis of the product. Glass wool made from waste is much cheaper than traditional products from sand, soda and limestone.
- Foam glass. High-quality insulation, produced in the form of granules, blocks, sheets, etc. The technology for the production of foam glass from glass battle is quite simple. The waste is crushed, melted and foamed in special plants with subsequent cooling.

- Liquid glass. A universal material that is used in various industrial and domestic fields. Silicate glue - this is liquid glass. In construction, it is used for waterproofing, as an additive in concrete, etc. Cullet replace sand in the production of liquid glass, which reduces the cost of production.
- Interior tiles. From waste glass can produce excellent tiles for finishing work. The production technology is elementary: ground glass is mixed with a special resin and poured into molds for hardening. The tile has an "expensive" appearance and has water repellent properties.

Of course, this is not a complete list of products that can be made from glass waste, but this is the most popular product based on glass battle [28].

2.8 Rubber Processing

Rubber processing. The problem of waste management including rubber waste in modern society remains significantly important, despite the development of technology for the production of new technologically advanced and, to the extent, environmentally safe products [33].

Warehousing and disposal and burial of waste is economically inefficient and environmentally unsafe, since during long-term storage they can release substances into the environment that can lead to a violation of the ecological balance.

In addition, at the moment rubber products lose their operational properties and qualities, the polymer material itself undergoes very insignificant structural changes, which makes it possible and even necessary to recycle them.

The most promising methods of processing waste rubber products associated with their grinding, as chemical methods such as pyrolysis and burning lead to the destruction of the polymer base of the material.

Various grinding methods can be divided into cryogenic grinding and grinding at positive temperatures depending on the process conditions. Despite the possibility of obtaining fine powders of rubber and low energy consumption for the actual process of grinding vitrified rubber, cryogenic technology has a very significant drawback associated with the high cost of refrigerants [33].

Technological processes and equipment for the processing of used tires and other types of industrial and solid household polymer waste (waste products from rubber, textiles, leather, wood and other natural and synthetic polymers) are carried out at positive temperatures. The results of the study of various polymers and compositions showed the possibility of obtaining powders, short fibers and crumbs from them of varying degrees of dispersion and using them as additives (or bases) in the manufacture of new products [33].

It is known that in the region of positive temperatures at certain strain rates and the complex nature of loading, elastomers are destroyed with little energy, which is associated with a significant decrease in orientation effects. This gave reason to conduct extensive research in order to determine the ratio of the destruction energy of rubbers and rubbers in a single act and the energy spent on grinding.

The studies made it possible to substantiate the choice of a high-temperature high-speed deformation mode, in which the fracture work is of minimal importance. Based on the results obtained, the optimal design and technological parameters of the grinding processes are determined [34].

In addition to technological factors, the type of grinder and its design parameters have a significant impact on the process characteristics. The results of the study of the kinetics of grinding elastomers in various apparatuses made it possible to develop mathematical models of grinding processes in apparatuses of periodic and continuous operation and engineering methods for calculating the productivity of the corresponding apparatuses, to select effective areas of application of grinders to obtain products of various degrees of dispersion from various elastomers and composite materials based on them, to create scientific basis of the processes of mechanical grinding of elastomers of various genera and to determine ways of application of this process in the rubber industry [34].

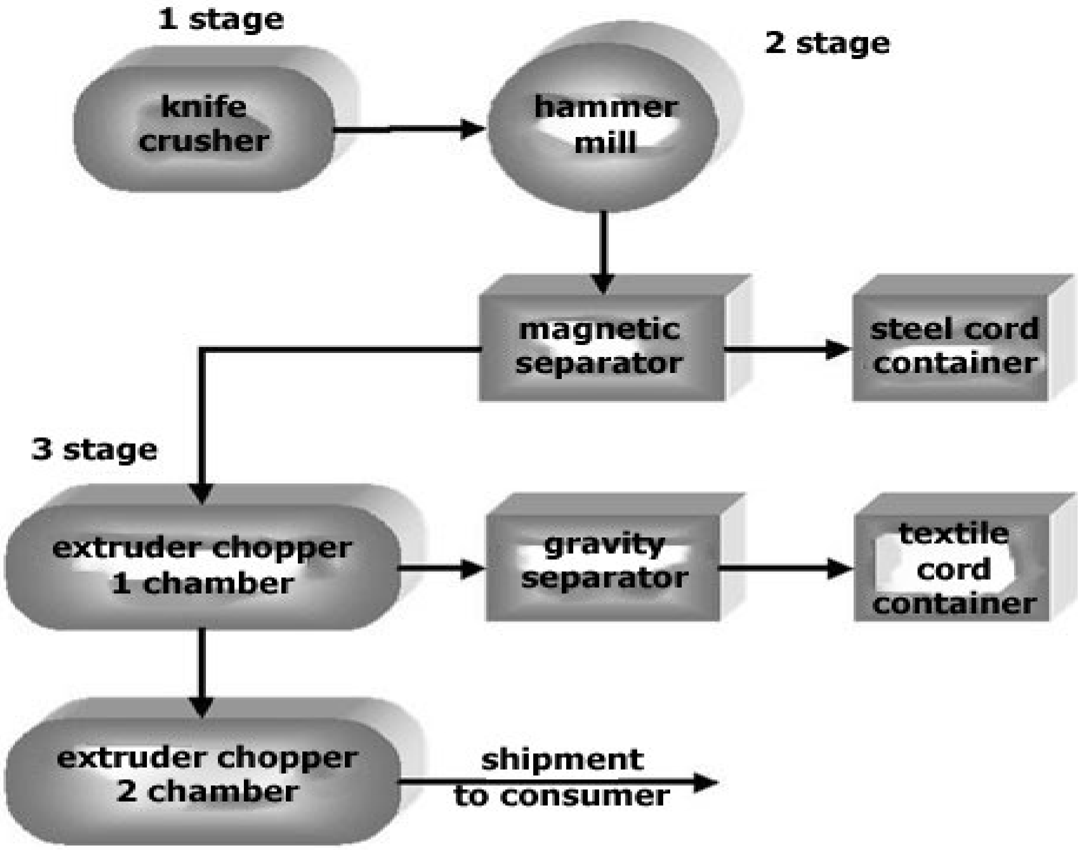


Fig. 2.14. Rubber Processing

The following main groups and types of rubbers are distinguished by purpose:

By groups:

General purpose, special purpose, including:

• heat resistant;

• frost resistant;

• oil and petrol resistant;

• resistant to chemically aggressive environments, including resistant to hydraulic fluids;

• dielectric;

• electrically conductive, including antistatic;

• magnetic;

• fire resistant;

• radiation resistant;

• vacuum;

• frictional (wear-resistant);

• food and medical purposes;

For tropical and other climates

By type: also receive

• porous, or spongy

• colored and transparent rubber.

The composition of the rubber compound determines the properties of rubber products.

Rubber compounds are available in uncured form, rolled or calendered:

• rolled - in the form of sheets with a size of (500x700) mm, a thickness of 6 to 10 mm, the weight of one packaging unit is from 30 to 50 kg;

• calendered - in the form of a rubber web wound into a roll: the thickness of the calendared web is from 1.0 to 4.0 mm, the width of the calendared web is from 500 to 1200 mm, the mass of the roll is from 40 to 60 kg.

The dynamic growth of the fleet in all developed countries leads to the constant accumulation of worn-out automobile tires. According to the European Tire Recycling Association (ETRA), in 2000, the total weight of worn but unprocessed tires reached [35]:

• in Europe, 2.5 million tons;

• in the USA - 2.8 million tons;

• in Japan, 1.0 million tons;

• in Russia - 1.0 million tons.

Obsolete worn-out tires are a source of long-term environmental pollution:

• tires are not biodegradable;

• tires are flammable and, in case of fire, it is rather difficult to extinguish them;

• when stored, they are an ideal breeding ground for rodents, blood-sucking insects and serve as a source of infectious diseases.

At the same time, shock-absorbed car tires contain valuable raw materials: rubber, metal, textile cord.

The problem of recycling worn-out tires and retired rubber products is of great environmental and economic importance for all developed countries of the world. The irreplaceability of natural petroleum raw materials necessitates the use of secondary resources with maximum efficiency, i.e. instead of mountains of garbage, we could get a new industry for our region - commercial waste processing [35].

An equally promising method of combating the accumulation of worn-out tires is to extend their service life by restoring [36].

1. Methods of processing rubber waste.

Currently, all known tire recycling methods can be divided into two groups:

1. Physical tire recycling method.

2. Chemical tire recycling method.

Physical methods for processing rubber waste. At present, the direction of the use of waste in the form of dispersed materials is becoming increasingly important. Most fully, the initial structure and properties of rubber and other polymers contained in the waste are preserved by mechanical grinding [35].

Establishing the relationship between the particle sizes of the material, their physicochemical and mechanical characteristics and the energy consumption for grinding and the parameters of the grinding equipment is necessary to calculate the grinders and determine the optimal conditions for their operation.

The grinding process, despite its apparent simplicity, is very complicated not only by determining the nature, magnitude and direction of the loads, but also by the difficulty of quantifying the results of failure.

Below is a classification of the currently available methods of grinding secondary rubbers [36].

Methods of grinding secondary rubbers. By grinding temperature:

• At low temperatures

• At positive temperatures

By mechanical action:

• Blow

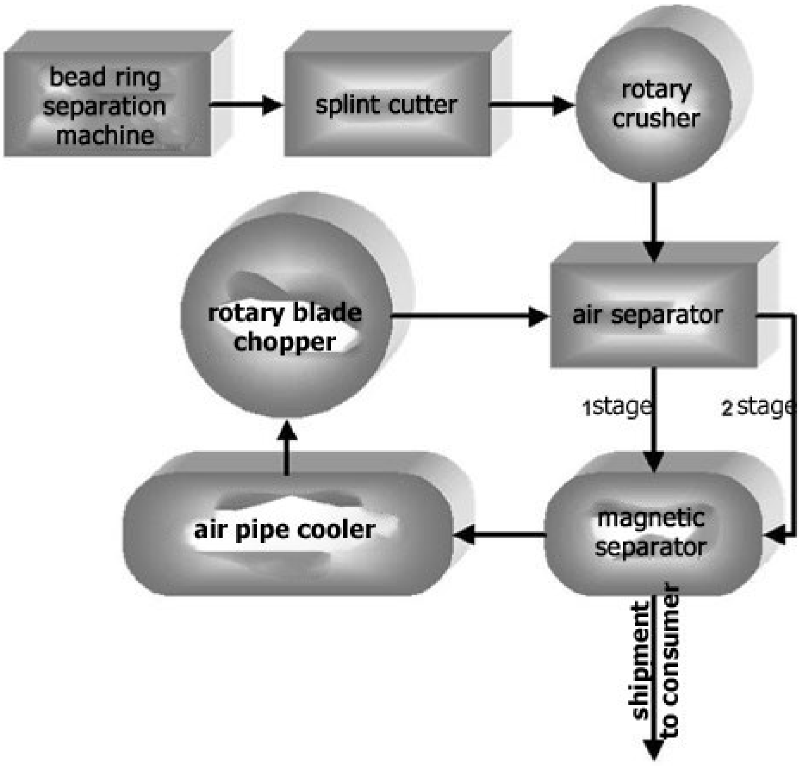
• Abrasion

• Compression

• Compression with shift

• Cutting

According to this classification, we consider the following technologies:

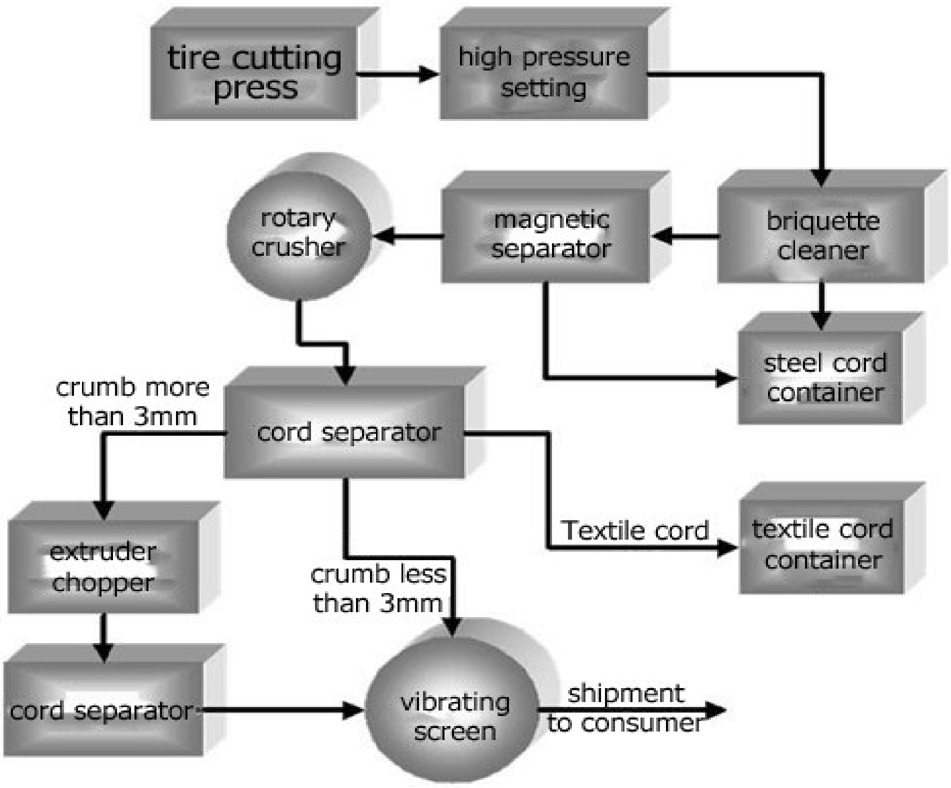


2.15. Low Temperature Tire Recycling Technology

During low-temperature processing of worn tires, crushing is carried out at temperatures of -60 ° C ... -90 ° C, when the rubber is in a pseudo-brittle state. The experimental results showed that crushing at low temperatures significantly reduces the energy consumption for crushing, improves the separation of metal and textile from rubber, and increases the yield of rubber. In all known installations, liquid nitrogen is used to cool the rubber. But the complexity of its delivery, storage, high cost and high energy costs for its production are the main reasons that currently hamper the introduction of low-temperature technology. To obtain temperatures in the range of -80 ° C ... -120 ° C, turbo-refrigerating machines are more efficient. In this temperature range, the use of turbo-refrigerating machines reduces the cost of obtaining cold by 3-4 times, and the specific energy consumption by 2-3 times compared with the use of liquid nitrogen. The technology is not implemented. Line productivity 6000 t / year [36].

Description of the tire processing line. Worn car tires are fed into the machine to remove the side rings. After this, the tires enter the tire cutter and then into the rotary knife crusher. This is followed by a magnetic separator and air separator. For cooling, cut and pre-cleaned pieces of rubber are fed into a refrigerator, where they are cooled to a temperature of -50 ° C ...- 90 ° C. Cold air for cooling the rubber is supplied from the cold generator of an air turbo-refrigerating machine. Then, the cooled rubber gets into the rotor-blade shredder, from where it is sent for re-cleaning to the magnetic separator and the air separator, where less than 1 mm ... 0.5 mm rubber crumb is selected, as well as the larger one and packaged in bags and sent to the customer [37].

Barode destruction technology for tire processing. The technology is based on the phenomenon of "fluidization" of rubber at high pressures and its expiration through the holes of a special chamber. In this case, rubber and textile cord are separated from the metal cord and bead rings, crushed and come out of the holes in the form of primary rubber-fabric crumb, which undergoes further processing: regrinding and separation. The metal cord is removed from the chamber in the form of a compressed briquette. Line



productivity 6000 t / year [37].

Fig. 2.16. Tire Processing Line

Description of the production line:

The tire covers the press for cutting tires, where it is cut into fragments weighing no more than 20 kg. Next, the pieces are fed to a high-pressure unit.

In a high-pressure installation, the tire is loaded into the working chamber, where the rubber is extruded in the form of pieces 20-80 mm in size and the steel cord is separated [38].

After the high pressure is installed, crumb rubber and metal are fed into the briquette cleaning apparatus to separate the metal cord (enters the container) from rubber and textile cord, and the side rings are selected. Then the rest of the mass is fed into a magnetic separator, where the bulk of the belt metal cord is captured. The remaining mass is fed into a rotary crusher, where the rubber is crushed to 10 mm.

Then again to the cord separator, where the rubber is separated from the textile cord and the rubber crumb is divided into two fractions:

- less than 3 mm;
- from 3 to 10 mm.

The textile cord separated from the rubber enters the container.

If rubber crumb with a fraction of more than 3 mm is of interest to the consumer as a marketable product, then it is packaged in paper bags, if not, then it falls into the extruder-grinder [37].

After grinding again into the cord separator. Textile cord - in a container, and crumb rubber - in a vibrating screen, where it is further divided into three fractions:

I - from 0.3 to 1.0 mm;

II - from 1.0 to 3.0 mm;

III - over 3.0 mm.

A fraction of rubber crumb more than 3 mm is returned to the extruder-grinder, and rubber crumb I and II fractions are shipped to the buyer [37].

Fully mechanical tire recycling. The processing technology is based on the mechanical grinding of tires into small pieces, followed by the mechanical separation of the metal and textile cord, based on the principle of "increasing brittleness" of rubber at high impact speeds, and the preparation of fine rubber powders up to 0.2 mm in size by extrusion grinding of the resulting rubber crumb. Line productivity 5100 t / year [36].

Description of the production line:

The technological process includes three stages:

• pre-cutting tires into pieces;

• crushing of pieces of rubber and separation of metal and textile cord;

• obtaining fine rubber powder.

At the first stage of the technological process, the tires coming from the warehouse are fed to the tire preparation section, where they are washed and cleaned of foreign inclusions.

After washing, the tires enter the preliminary grinding unit - units of a three-stage knife crusher, in which the tires are subsequently crushed to pieces of rubber, the dimensions of which do not exceed 30x50 mm [36].

At the second stage, pre-crushed pieces of tires are fed into a hammer mill, where they are crushed to a size of 10x20 mm. When crushing pieces, the mass processed in a hammer mill is divided into rubber, metal cord, bead wire and textile fiber [36].

The crumb rubber with the selected metal enters the conveyor, from which free metal is removed using magnetic separators and enters special bins. After that, metal waste is briquetted using a briquetting press (baling press).

In a third step, pieces of rubber are fed to an extruder grinder. At this stage of processing, parallel separation of the textile fiber residues and its separation by means of a gravitational separator from rubber crumb occurs. The rubber powder purified from textiles is fed into the second chamber of the extruder-grinder, in which the final fine grinding takes place.

Upon exit from the extruder - into a vibrating screen, and where the sifting of the powder into 3 fractions is carried out.

1st fraction -0.5 ... 0.8 mm

2nd fraction - 0.8 ... 1.6 mm

3rd additional fraction - 0.2 ... 0.45 mm (delivery on request)

1.6. The latest tire recycling technology

The gold medal of the 26th International Salon of Inventions, held in the spring of 2000 in Geneva, was awarded to the method of ozone processing of used tires, proposed by a group of Russian scientists and engineers. The essence of the technology is to “blow through” automobile tires with ozone, which leads to their complete scattering into small crumbs with separation from the metal and textile cord.

At the same time, the new technology is much more economical than all existing ones and, in addition, absolutely environmentally friendly - ozone oxidizes all harmful gaseous emissions. Two experimental ozone plants have been created in Russia; their total productivity is about 4 thousand tons of crumb rubber per year [37].

Worn-out car tires as a secondary energy resource (chemical processing methods)

We are talking about methods that lead to deep irreversible changes in the structure of polymers. As a rule, these methods are carried out at high temperatures and consist in the thermal decomposition (destruction) of polymers in a given medium and the production of products of various molecular weights. These methods include burning, cracking, pyrolysis.

Possible uses for rubber crumb:

• powder rubber with particle sizes from 0.2 to 0.45 mm is used as an additive (5 ... 20%) in rubber compounds for the manufacture of new car tires, solid tires and other rubber products. The use of rubber powder with a highly developed specific surface area of particles (2500-3500 cm2 / g) obtained by mechanical grinding increases the resistance of tires to bending and impact, increasing their service life;

• powder rubber with particle sizes up to 0.6 mm is used as an additive (up to 50 ... 70%) in the manufacture of rubber shoes and other rubber products. Moreover, the properties of such rubbers (strength, deformability) practically do not differ from the properties of ordinary rubber made from raw rubbers;

powder rubber with particle sizes up to 1.0 mm can be used for the manufacture of composite roofing materials (roll roofing and rubber slate), linings for rails, rubber-bitumen mastics, vulcanized and non-vulcanized roll waterproofing materials;

• powder rubber with particle sizes from 0.5 to 1.0 mm is used as an additive for the modification of petroleum bitumen in asphalt mixtures.

Some results of the study of its influence on the performance properties of asphalt concrete should be given. In the study, we studied the effect of the amount of rubber crumb introduced into the asphalt mix by the number and size of particles on the crack resistance of asphalt concrete and the coefficient of adhesion of the car wheel to the surface of the carriageway.

- It is established that the use of crumb rubber in asphalt concrete doubles the coefficient of adhesion on wet surfaces. There are no significant changes on dry surfaces.
- When using rubber crumb from 0 to 1.0 mm, crack resistance increases by 30 percent. With decreasing particle size, crack resistance increases. Particularly effective is the use of crumb particles of 0.14 mm or less. Particles less than 0.08 decay during mixing, the components modify the bitumen, improving its properties.
- With small particle sizes, the crumb is distributed over the mass of the asphalt mixture more uniformly increasing the elastic deformation at low temperatures.
- The volume of crushed rubber in such advanced coatings should be about 2% by weight of the mineral material, i.e. 60 ... 70 tons per 1 km of the roadway. At the same time, the life of the roadway is increased by 1.5 - 2 times.

Such powders (particle sizes from 0.5 to 1.0 mm) are also used as a sorbent for collecting crude oil and liquid oil products from the surface of water and soil, for plugging oil wells, waterproofing green formations, etc; crumb rubber with particle sizes from 2 to 10 mm is used in the manufacture of massive rubber plates for manning tram and railway crossings, which are distinguished by their long service life, good weather resistance, low noise level and modern design; sports grounds with a convenient and safe coating; livestock buildings, etc [39].

2.9. Conclusion to Chapter 2

In this section, we have looked at standard waste management methods. It deals mainly with the wastes that are infused in everyday life, such as: paper, plastic and glass bottles, car tires. These are all recycling methods that will help humanity to properly treat waste and not dispose of it in landfill.

CHAPTER 3
TECHNOLOGIES OF MSW REUSE IN CONSTRUCTION INDUSTRY

3.1 Current waste technologies treatment in construction industry

Strong durable roofs, pipes, pavements, and finally, cheap and efficient electrical insulators can be made almost from rubbish - old plastic bottles, disposable cups, broken bricks and ash. In fact, this means the ability to utilize plastic materials, turning garbage into the most valuable raw materials for industry, mainly construction.

The fact is that polyethylene terephthalate, the so-called PET, does not rot in nature, does not corrode, and practically does not oxidize. When burned, it burns with the formation of very toxic substances. Using it a second time is either difficult or expensive - after direct processing, PET loses its strength, and only very expensive components help maintain it.

Table 3.1

Waste recycling in construction industry

Type of waste	What we can produce?
Glass	asphalt additive construction ceramics panel of the house decorative cover
Crushed fiberglass waste	brick
Worn car tires	insulation and roofing material. waterproofing material paving slabs
Plastic bottle	paving slabs walls fittings
Polystyrene	Polystyrene concrete

3.1.1 Polystyrene concrete manufacturing technology

Lightweight concrete with expanded polystyrene aggregate - known as polystyrene concrete, is lightweight concrete with a mineral binder, the pores of which are formed by particles of expanded polystyrene foam used as aggregate. The extremely low bulk density of the particles of foamed plastic allows the production of lightweight concrete with a bulk density, the range of which can be selected in accordance with the requirements of a particular application, while the concrete has a correspondingly wide range of characteristics.

Lightweight concrete with expanded polystyrene aggregate (polystyrene concrete), heat-insulating plasters based on expanded polystyrene concrete have been known for a long time. While polystyrene concrete has been known for at least 25 years in our market, and in the west for more than 40 years, until now, expectations regarding the volume of use of polystyrene concrete have been met only in some areas of application. However, in the building materials industry, there has been an increase in interest in polystyrene concrete, indicating some changes in this regard, mainly due to the following reasons:

- polystyrene concrete has become a serious alternative to foam concrete and aerated concrete, due to its wider scope, ease of manufacture and significantly better material characteristics
- requirements for thermal insulation of buildings become much more stringent, as a result of which it became necessary to functional separation of building materials into heat-insulating and bearing load, and these materials must be combined in the elements of buildings accordingly. In this regard, the use of lightweight concrete with expanded polystyrene (polystyrene concrete) aggregate offers interesting solutions.

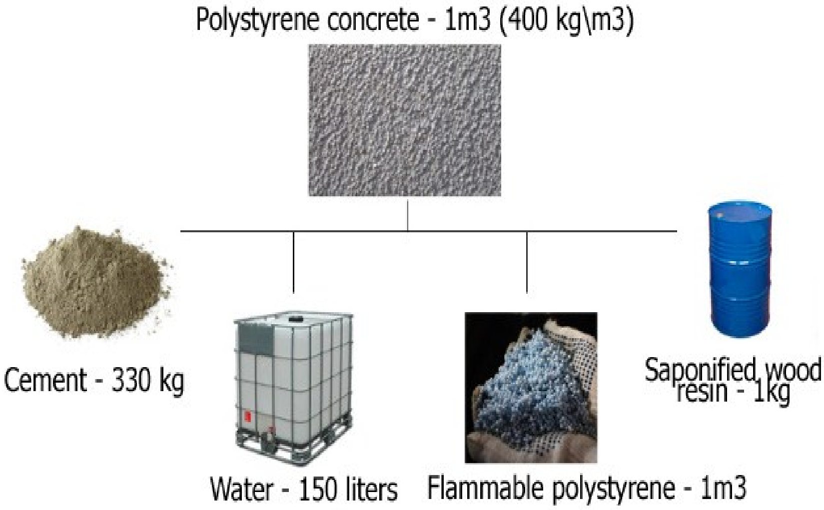


Fig.3.1. Composition of polystyrene concrete

This article discusses the current state of polystyrene concrete production technologies, paying due attention to the use of recycled polystyrene, as well as recently developed systems based on polystyrene concrete.

Description of polystyrene concrete. Lightweight concrete with polystyrene foam aggregate is part of the group of extremely lightweight concrete, which are produced using porous aggregates, usually having low grain strength. The decisive factor for the strength properties is the structure of the hardened cement paste surrounding the particles of aggregates made of foamed plastic, and affecting the mass of concrete. In addition, the shape and size of the grains, as well as the surface structure of the polystyrene foam aggregates used, are important. Unlike mineral aggregates, the dosage of polystyrene foam aggregates is set not by weight, but by volume. Thus, it is possible to precisely set the pore volume and, due to this, the bulk density of polystyrene concrete, and to produce polystyrene concrete having a structure with closed pores. By choosing the bulk density of concrete, the characteristics of polystyrene concrete can be influenced to better meet specific requirements. In the light of today's requirements, polystyrene concrete is of interest, with a bulk density in the lower range (<600 kg / m3). In this case, the combination of <heat-insulating material> and <concrete> in one material offers builders an optimal combination of load-bearing properties, sound insulation, thermal insulation and fire protection. Already several years after the invention of polystyrene foam concrete, called Styropor (1951), BASF conducted the first indicative tests on the use of expanded polystyrene as a filler for the production of polystyrene concrete (styrene concrete). Since the high cost of this raw material initially did not allow its cost-effective use as a lightweight aggregate, new studies began at the end of 1967, and their intensity began to gradually increase. By this time, lightweight expanded polystyrene aggregates had become an interesting alternative to lightweight mineral aggregates, and even despite their price, there was a growing interest in new polystyrene concrete building products. To create the necessary prerequisites for their entry into the market, BASF has taken the following measures:

- development of formulations of various polystyrene concrete mixtures, allowing to reproduce them in practice
- confirmation of all important characteristics of building material by tests conducted by official organizations
- development and distribution of cooking and styling methods
- implementation and evaluation of practical tests in order to confirm the success of the application
- assistance and technical advice for material manufacturers regarding the development of production systems.

All these measures have been taken in our country and there are all prerequisites for the active use of polystyrene concrete. In contrast to lightweight concrete with mineral aggregates, foam concrete, aerated concrete, in the case of polystyrene concrete, it is possible to produce lightweight concrete with a bulk mass of less than 200 kg / m3, and therefore good thermal insulation characteristics. As a result of this, further development is concentrated on the production of polystyrene concrete falling into this lower range of bulk masses, and in particular, on improving the properties of lightweight concrete with expanded polystyrene aggregate, production technology, and on the development of building systems using polystyrene concrete. Expanded polystyrene with a bulk density of 10-25 kg / m3, which does not affect the final strength of lightweight concrete, is used as a filler for polystyrene concrete. The grain size of the expanded polystyrene foam particles is in the range of 0.5-3.5 mm, which makes it possible to obtain a finely porous concrete skeleton, and raw material with a particle size of 0.2 to 1.0 mm is used. Lightweight polystyrene foam aggregate has the following characteristic properties:

- extremely low bulk density
- good thermal insulation of foamed particles, due to which there is practically no absorption of water
- spherical shape, which is preferred in terms of static loads.

However, in the range of very low bulk densities, the hydrophobic properties of lightweight closed-cell expanded polystyrene aggregates can have an adverse effect, since the low adhesion strength between the cement paste and the particle surface can lead to delamination of the polystyrene concrete during preparation and laying. In the early years of practical use, this effect was counteracted by the introduction of additives that improve adhesion. A number of manufacturers are going along this path, mainly trying to increase sales of additives, as Western manufacturers and some domestic manufacturers use special brands of expanded polystyrene with a large porous surface of particles or special devices that allow concrete without any such additives to be laid without objection.

Expanded polystyrene waste as a lightweight aggregate. In Germany, currently about 40,000 tons of raw materials are used for the production of packaging materials for the production of expanded polystyrene, from which expanded polystyrene is obtained in the amount of up to 2 million m3. These packaging materials contain 98% air, do not contain any amount of fluorocarbons, and can be recycled in order to serve any reasonable purpose again. In our country, there is also a sufficient amount of waste, and with the development of industry and an increase in the production of products, the issue of packaging recycling is acute. In this regard, systems have been developed for the recycling of expanded polystyrene, which allows for the complete disposal of used packaging materials received from industrial, commercial enterprises and from private consumers. In this article we consider only the use of polystyrene waste in lightweight concrete. Fine-grained <crushed material> made from polystyrene foam packaging production waste is suitable for use in the production of building materials: as a pore-forming substance in the production of blocks, panels, and as a lightweight aggregate for the production of lightweight concrete (polystyrene concrete).

To use ground polystyrene foam as a lightweight aggregate, certain requirements must be met in order to prevent concrete quality deterioration. In terms of grain size and shape, the differences between the <crushed material> and the freshly baked polystyrene particles should be as small as possible:

- most grains should be round
- most grains should have sizes ranging from 0.5 mm to 4.0 mm
- very fine particles should not be present in the crushed material.

These quality requirements can be met under the following conditions:

- using appropriate crushers to separate polystyrene particles in wheelbarrows in which they fused with each other, so that the initial spherical shape of the grains is very much preserved
- the particle size of the granules of polystyrene foam used for the production of packaging materials, usually corresponds to the size required for lightweight polystyrene foam aggregate made from "fresh material", this is achievable by using appropriate sieves in the crusher. Currently, such prepared <crushed material> is offered by some Western manufacturers of packaging materials at a price of 12 to 25 euros, which is much lower than the price level for freshly foamed lightweight polystyrene foam aggregate.

There is also <crushed material> on the Russian market, which unfortunately rarely meets the above requirements. The 28-day compressive and bending strengths obtained in each case are the average values for the three samples. The compressive strength tests were carried out on cubes with a rib length of 20 cm, and the flexural strength tests were performed on bars of 70 * 15 * 15 cm. The compressive strength of polystyrene concrete samples made using polystyrene foam from <crushed material> is primarily in the bottom part of the bulk density range of polystyrene concrete is about 40% lower than that of polystyrene concrete made using fresh expanded polystyrene foam particles. The tensile strength in bending of both versions of polystyrene concrete within the specified range of

Daensity, kg\m3	Coef. thermal conductivity Wt\(m*C) Operating conditions A	 Б	Vapor permeability mg\(m*ch*Pa)
200	0,07	0,07	0,135
250	0,07	0,08	0,12
300	0,1	0,11	0,1
400	0,12	0,13	0,085
500	0,14	0,16	0,075
600	0,18	0,2	0,068

bulk masses is approximately at the same level. The use of expanded polystyrene from <crushed material>, in comparison with expanded polystyrene foam, does not affect thermal conductivity, since it primarily depends on the bulk density of polystyrene concrete. The use of expanded polystyrene from <crushed material> does not adversely affect quality requirements, such as water absorption, frost resistance, fire resistance, etc.

Fig.3.2. Thermal conductivity and vapor permeation of polystyrene concrete

Like other varieties of lightweight concrete, depending on the average density, polystyrene products can be used as heat-insulating or structural material. This indicator can vary from 150 to 600 kg / m3.

The thermal conductivity of the dry material in this case begins to count from a numerical value equal to 0.05. In this regard, polystyrene concrete can be said to be a leader. The maximum value does not exceed 0.145.

The finished construction, constructed using polystyrene concrete, will, of course, have a large coefficient - in connection with being in a state of operational humidity. However, there will be no significant changes.

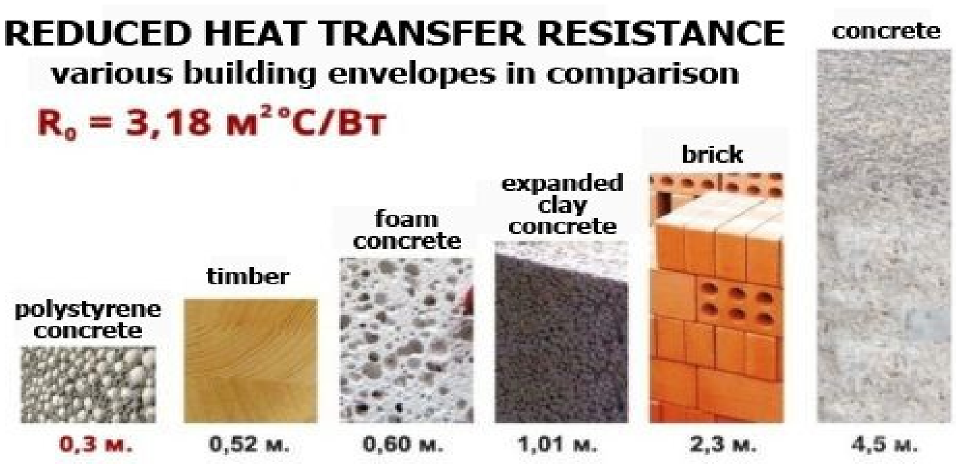


Fig.3.3. Comparison of the heat-saving characteristics of polystyrene concrete with other materials

Polystyrene concrete is characterized by a high frost resistance brand - it can reach 200. This means that products can withstand up to 200 cycles of time-freezing and thawing.

It is also worth noting that polystyrene concrete is an environmentally friendly material, it does not burn. However, it is not capable of withstanding the effects of high temperature for a long time.

The durability of the products leaves no doubt. Much depends on the manufacturer, operating conditions, the composition of the raw materials and the technically correct finish. However, subject to all standards, polystyrene concrete will last an extremely long time.

Strength grade is directly dependent on density. The minimum value established by GOST is 0.35.

Table 3.2

Technical properties of polystyrene concrete

Name of indicator	Value
Coefficient of thermal conductivity, W * mS	0.05-0.145
Average density, kg / m^3	150-600
Strength grade, V	0.35-5
Frost resistance, cycles	25-200
Shrinkage	Up to 1 mm / m^2
Water absorption	5-8%

Production of polystyrene concrete. In the beginning, a little about production technology. For the manufacture of any building blocks, polystyrene foam is no exception, it is better to use the pressing method, and even better vibropressing, material. This significantly increases its stability, which means a service life.

The production of polystyrene foam blocks can be performed in two main ways:

- Pouring solution into cassette forms.
- Volumetric vibropressing of hard mixtures.

In both cases, the stages of production of polystyrene concrete are similar, but there are some technological differences.

Injection manufacturing method is one of the methods for the production of polystyrene concrete blocks.

The most common method of manufacturing masonry material is casting in movable, plastic forms. At the filling site, the molds must be lubricated from the inside with special grease. When there is a need to pour the mixture into the formwork, it is installed directly in the place where it is advisable to use polystyrene concrete.

Typically, a cassette method for manufacturing polystyrene blocks involves the use of stable solutions of medium and low density. In the manufacture of a large number of blocks, it is advisable to use a foam generator.

This appliance can continuously supply foamed mortars to a concrete mixing tank. It is also necessary to fill in the right amount of PSV granules. Ready blocks of medium and low density have a fairly low coefficient of thermal conductivity.

The disadvantages of the technological process include only 2 facts:

- Good cassettes are expensive.
- It is quite difficult to get ready-made blocks from forms, which increases labor costs.

However, with a well-established manufacturing process for a large number of polystyrene blocks, these shortcomings are leveled due to production volumes.

Vibrocompression. For this method, it is only possible to use polystyrene mixtures with a low water content and large cement. The manufacture of blocks can only be done using vibropress equipment.

It happens like this:

- The prepared mixture is portioned into the molding machine.
- On molding pallets that change, the process of vibropressing to a semi-dry state occurs.
- Semi-finished products on pallets are sent to the drying chamber, where they withstand a certain time.

Finished polystyrene blocks have the most rigid density. Of the advantages of such a process:

- The quality of the blocks is the highest.
- There is no need to use cassette forms.

Do-it-yourself polystyrene concrete. This building material can be prepared no more difficult than cinder block. To prepare polystyrene blocks you will need:

- Concrete mixer.
- Crushed polystyrene.
- Cement.
- Sand.
- Water.

With your own hands, you can try to make polystyrene foam of densities D350 and D1200. In this case, the second composition is needed for the preparation of supporting structures, and the first is suitable for creating a heat-insulating material.

Expanded polystyrene D1200 in its composition has:

- 1.1 m^3 polystyrene foam crumbs,
- 300 kg of cement
- 800 kg of sand.

After hardening the material, a rather monolithic and strong block of lightweight concrete is obtained.

The D350 has the same volume of cement and chips, but it has less sand. Finished blocks are not suitable for supporting structures.

In any case, the steps for preparing polystyrene concrete are as follows:

- Making the mixture. Mix everything thoroughly in a concrete mixer for 20 to 25 minutes.
- Forming the mixture into cassette forms or formwork.
- Drying. In the summer, you need 2 to 3 days so that the finished blocks can be removed from the mold. In winter, a week, or even more.
- If necessary, sawing.

It's not just enough to grind the foam. It is easily electrified and sticks to objects. Therefore, if it is not possible to buy this material ready for the manufacture of polystyrene concrete blocks, then it should be borne in mind that:

- It is better to crush it with something rather heavy and it's nice to place the sheets in some big bag. In this case, a heterogeneous crumb, possibly a large fraction, will be obtained.
- If the foam is needed small and uniform, then you can rub it, for example, on the bottom of a plastic box intended for transporting fruit.
- Polystyrene concrete blocks of own production may not be as smooth as factory ones and their percentage of strength will most likely be lower. Nevertheless, they

can be used for the construction of various objects of private housing construction. Their laying out of walls is somewhat different from ordinary masonry, say, cinder block.

- There are factory-made crushers. The principle of operation is that a layer is fed to the cutting tool, which is crushed there. Everything is simple and fast, subject to

safety regulations. But this device is quite expensive and its acquisition is advisable in the production of polystyrene blocks in large quantities.

Fig.3.4. Mini polystyrene concrete plant

The simplest and most inexpensive set is a set of concrete mixers, raw materials and molds for products. If it is planned to release products that exceed the volume of 25-30 m3 per day, it will be necessary to purchase a foam generator that can ensure an uninterrupted supply of the mixture.

3.1.2 Production of paving slabs from plastic bottles: environmentally friendly and practical

The production of paving slabs from plastic bottles is a solution to a number of problems. Firstly, recycling. Previously, it accumulated in huge quantities and occupied kilometers of free area, but now it is beneficial. Secondly, this is the production of budget finishing material: there is no shortage of plastic, the remaining components are inexpensive. Thirdly, the technology allows you to create products of any shape and size - new opportunities for landscape design are opening up (sand-plastic paving slabs are street). What attracts consumers in it, details of industrial and private production, features of paving with paving slabs - this is what interests potential buyers.

The main characteristics of the material. In many of them, the material compares favorably with similar products. First of all, it should be noted that it is an environmentally friendly product. During its operation, no emissions of carcinogenic substances hazardous to human health are observed.

The tile is able to withstand repeated freezing, without losing its properties. The material, despite its considerable strength, is quite ductile. It is highly resistant to the aggressive effects of acids and other chemically active substances.

The substance of the product does not soften as a result of heating by sunlight. Its surface does not slip, as it has a good grip with the sole of the shoe.

Another positive coating quality is maintainability. A damaged element can easily be replaced with another. The material does not fade under sunlight and is preserved in its original form. The presence of a variety of colors helps tile can be used to solve any design project. It is used in the refinement of a variety of landscapes.

In the manufacture of the material, the ratio of the raw materials used is as follows:

- Sand - 94 parts;
- Plastic - 5 parts;
- Dye pigment - 1 part.

What polymer raw materials can be used. Having decided on the manufacture of tiles at home, you should worry about the presence in sufficient quantities of not only sand, but also plastic. If there are not enough plastic containers in your household, this is not a problem. Polymer trash can be found in the area, especially a lot of it in natural dumps. In extreme cases, it can be purchased, and not for a lot of money, at collection points for recyclables.

Plastic waste does not need sorting and cleaning. Under the influence of high temperatures during melting, paper or food debris will burn and will no longer affect the quality of the finished product.

The production of paving slabs, both industrial and independent, from plastic bottles allows the use of any polymer material. Including the old plastic wrap or bags. It is desirable that half of the composition of the raw materials were hard polymers, such as:

- Polypropylene;
- Polystyrene.

What is needed for production. In order to obtain high-quality, durable and reliable material, it is necessary to have special equipment available, use good raw materials in the correct proportions, and also properly ensure the drying process in natural conditions. So, from the equipment you will need:

- high-quality forced-action concrete mixer;
- vibration table - purchased or manufactured independently;
- various forms for tiles, differing in styles and sizes;
- ten-liter bucket;
- pick spade;
- working rubber gloves.

An important role here is played by correctly selected components. For the production of paving slabs you will need:

- high-quality crushed stone of hard non-metallic rocks of a fraction of three to ten millimeters;
- cement of 500 or 400 grades, not containing any additives;
- high quality cleaned sand;
- plasticizing and modifying additives;
- pure water;
- dyes in powder form;
- special grease for molds.

Stages of the production process. The technology of manufacturing paving slabs with their own hands implies the implementation of all the important steps in a certain sequence:

- first of all, the forms for the tiles are prepared properly;
- then a high-quality concrete mixture is prepared;
- then, on a special vibrating table, the tiles are molded;
- after that, for two or three days the material is kept in molds;

the final stage is the process of dismantling the finished tiles.

Fig.3.5. Forms of galvanized metal

You can use forms made of different materials - polyurethane, silicone, galvanized metal or fiberglass. Before filling with concrete mix, they must be lubricated with a special compound. You can cook it yourself - for this you need to add 50 g of engine oil to one and a half liters of water and mix for a long time until the mass becomes homogeneous. As a lubricant, vegetable oil can also be used, or a traditional laundry soap carefully ground and dissolved in water. The quality of future tiles depends on how correctly the concrete mix is kneaded. In the manufacture of paving slabs with their own hands, the proportions should be as follows:

- 9 buckets of finely fractioned gravel;

- 50 kg of cement grade 500;
- 250 mm plasticizer;
- 6 buckets of clean river sand, free of impurities;
- water - until the necessary consistency is obtained.

Forms filled with such a solution must be aged for three days. During this period, they should be periodically moistened with water to maintain the desired level of humidity. After removing the finished tiles, they must be dried naturally in about one month - so they will gain the necessary strength and other important quality indicators. Observing all the rules, you can quickly learn how to make paving slabs of any shape, size and shade. High-quality exclusive products will always be in high demand.

3.1.3 Production of rubber crumb tiles

Fractional rubber crumb is the basic raw material for the manufacture of tiles and rubber coatings. This raw material is actually taken from waste, or rather it is extracted by processing old worn tires from cars. Car tires are made from fairly expensive high-quality components (various oils, synthetic rubber, fillers), since these products must withstand huge loads for a very long period of time.

Of all the existing types of rubber, tire, in its structure, stands out for its high strength and resistance. Such rubber easily tolerates the ingress of acid and alkaline solutions to its surface, is very flexible, does not stretch, does not bend and is able to withstand temperatures from -45 to + 60 degrees.

Raw materials. Car crumb (or crushed rubber - RD) - is mined as a result of the processing of worn tires of other rubber goods. Its price depends on such indicators as: quality, manufacturing method, dimensions, place of manufacture and sale. In Russia, the retail price for crumbs varies in the district 6-15 rubles per kilogram.

Place of production of rubber crumb:

- factories that process car tires into crumbs, as the main raw material;
- for secondary production at RTI plants

- factories that restore tires by shering them (tread treatment) as a waste of production.

Used fractions of rubber crumb. Fractions of rubber crumb vary from 0.1 mm to 10 mm and directly depend on their purpose. So, fractions of a small type (0.1 - 4 mm) are mainly used in the production of colorless (black) or colored products of a single-layer nature. In the manufacture of the lower color layers, mainly larger fractions (2-10 mm) are used. Most often, they are cheaper in comparison with the smaller fractions, so they can include textile or metal inclusions. The production of tiles with two layers (upper thin color layer, lower dark layer with large fractions of crumbs) is acceptable and relevant when the original thickness of the product exceeds 1.5 cm.

Layering allows you to reduce the cost of the product due to the following points:

• Inclusion in the composition of cheap large fractions of crumbs. Such a crumb may include textile or other inclusions.

• Housekeeper on paint - the bottom layer remains black.

• Larger fractions of crumbs require less binder to stitch them, which is carried out by enveloping the surface of the crumb particles

• The absence of dye allows the use of less binder for crosslinking particles, since the mixture dries in the colored chips.

Coatings can be made:

- both soft and hard in density;
- waterproof, or with a pass of water (drainage);
- thin and thick;
- as colorless (black), colored, or black interspersed with different colors;
- with good grip, and more slippery;
- with or without a pattern;
- single-layer or with several layers;
- for laying on a soft base (soil) or hard;
- with connections (sleeve, lock) or without them.

Paving rubber tiles are often laid in parallel with conventional paving tiles. It is for such a combination that rubber coatings of similar sizes and shapes are created as ordinary tile for sidewalks.

Advantages and disadvantages of rubber coating. When choosing a material for laying garden paths with rubber filling, it should be said about the many advantages that it has. Among them:

a) Safety of use. The surface does not slip. It dries quickly. Therefore, you can safely walk along such a path in any weather.

b) Resistance to environmental influences. Rubber is not afraid of rain, temperature, humidity. It does not rot.

c) Easy to clean. Garbage can be swept away with a broom. Serious dirt is removed with a detergent brush.

d) Wide price range. Domestic production will be cheaper, and imported products a little more expensive.

e) Long term of operation. High-quality products will last from 50 years and above, without losing color and other initial properties.

f) Environmental friendliness. The rubber coating does not evaporate when heated harmful substances.

g) Easy installation. Laying tiles is the strength of one person.

h) Coating strength. Due to the elasticity, the rubber does not deform, does not break at the edges. Ensuring good sound insulation when moving people, transporting tools.

i) Easy to repair. The choice of shapes, colors. The ability to create on the track whole compositions, drawings.

3.2 Alternative for construction industry

The bottles themselves must first be cut into ribbons. To make it more convenient to twist them into the reinforcement, it is better to make tapes of medium width - up to 10 mm.

Method 1: the easiest. We take some ribbons and connect them into a bundle. The number of tapes in a bundle depends on what thickness of reinforcement you need.

Under the influence of hot air (a building hair dryer is required), we twist our hands around a small “tail”.

Next, the end of the resulting twist is carefully cut with scissors and inserted into the chuck of a screwdriver or drill.

Then we twist the tapes into the reinforcement. As a result, we got a ribbed bar. Such a "relief" will allow concrete to cling to it better.

Fig.3.6. Technological scheme of fitting production (method 1).

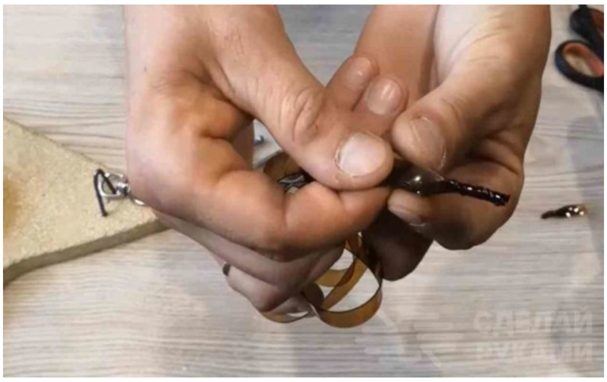
Method 2: More Reliable. We take a plastic tape about 10-12 mm wide and fold it in half.

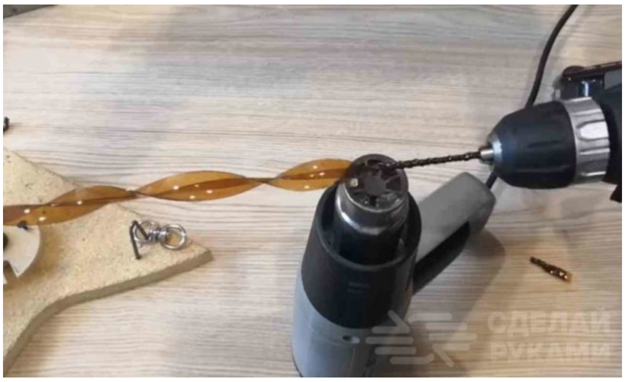
On one of the sides we make a “tail” and trim the end so that you can insert it into the drill or screwdriver's chuck.

The other end of the tape clings to a steel hook. And then we begin to twist it, holding it above the hairdryer.

When they twisted the plastic cable, we hook the hook on the swivel. We take one more tape, we pass its end in a bend from the first tape, after which we begin to wind up.

When they wrapped the entire tape, we tie its end to a knot, and heat the fittings with a hairdryer.





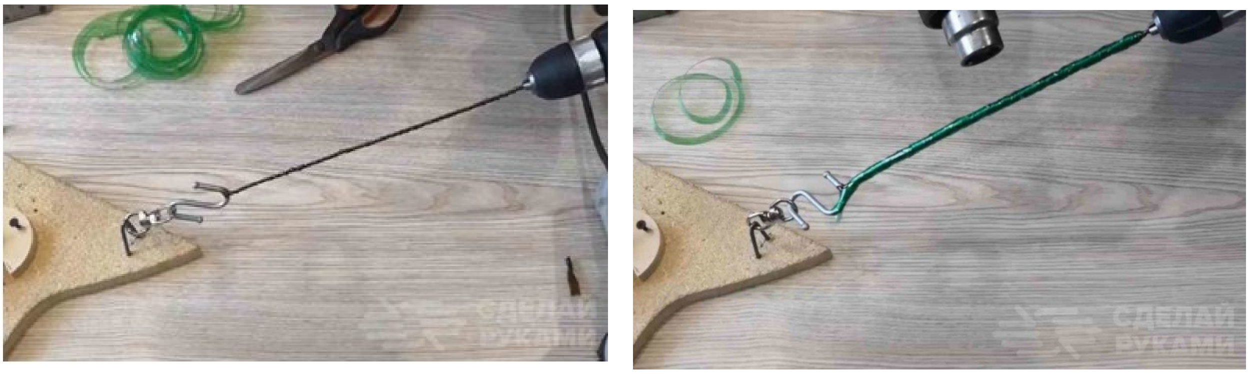


Fig.3.7. Technological scheme of fitting production (method 2).

3.3 Advantages and disadvantages of plastic construction materials

The building material industry is a domain of interest for using the wastes and researchers have tried to produce new construction materials incorporating wastes. The new generation of building materials is developing on other theories in concordance with the sustainability of environment.

The building and construction sector in Europe consumes around 10 million tonnes of plastics each year (20% of total European plastics consumption), making it the second largest application for plastics after packaging. Plastic pipes, for instance, account for the majority of all new pipe installations, with well over 50% of the annual tonnage. And this share continues to grow.

Although plastics are not always visible in buildings, they are used in a wide and growing range of applications, including insulation, piping, window frames and interior design. This growth is mainly due to plastics' unique features, which include:

- *Durability and resistance to corrosion.* The durability of plastics makes them ideal for applications such as window frames and pipes. Furthermore, their anti-corrosion properties provide them with an impressive life span, extending to more than 100 years for plastic pipes and 50 years for underground and exterior cables.
- *Insulation.* Plastics provide effective insulation from cold and heat, prevent energy leakage, and allow households to save energy while also reducing noise pollution.

- *Cost efficiency.* Plastics components often cost less than traditional materials to produce and install, even in custom-made forms.
- *Hygiene.* Plastic pipes are ideal for the safe and hygienic transportation of water. Plastics are also the ideal choice for hygienic household surfaces and floor coverings as they are easy to clean and impermeable.
- *Sustainability.* Plastics save resources through their cost-effective production, ease of installation and durability. In a typical house, it is estimated that the amount of energy used to produce its plastic insulation products is recouped after only one year of use. Moreover, these plastics can be re-used, recycled or converted into energy.
- *Innovation.* Plastics inspire architects to create buildings with innovative designs, features and dimensions. Moreover, the rapid pace of innovation in plastics helps to continually reduce the costs and increase the efficiency of buildings.
- *Easy to install, use and maintain.* Plastics are easy to install, operate and maintain thanks to their light weight. In fact, maintenance can often be dispensed with. Furthermore, the flexibility of plastics means that plastic pipes can cope with soil movements.
- *Fire safety.* Many plastic products in the building and construction sector are valued because of their fire resistance. Smoke detectors, alarms and automated firefighting systems are largely made of plastics and the success of PVC, the leading polymer in the sector, is largely due to its intrinsic fire safety characteristics. Furthermore, the Fire Safety Engineering approach – which assesses the fire behaviour of a product in different scenarios in a defined environment – is expected to be introduced into regulations, stimulating the further use of plastics to improve fire safety.

The plastic materials represent today an important category of waste. Most of them are re-used in different domains. Polypropylene, polyethylene, polyvinyl alcohol, polyvinyl chloride, nylon, aramid, polyesters are used as short plastic fibers in concrete elements. In the concrete production these fibers are currently used for obtaining high strength concretes, shotcrete, self-compacting concrete, etc [35]. Polyethylene terephthalate (PET) is one of the most used plastic in the entire world, especially for obtaining beverage containers, which are generally thrown away after single usage and their disposal creates serious problems to the environment. Some PET wastes are recycled for obtaining new products, other wastes are used as short fiber reinforcement in structural concrete, also as synthetic coarse aggregates for lightweight concrete, or as resin for polymer concrete [35].

3.4. Conclusion of the chapter 3

This section looks at the technologies used in the construction sphere. It was shown from what kind of garbage what kind of build material we could get. Technology was also proposed for the conversion of plastic bottles into alternative replacement valves. Technology is shown how to produce it. Analyzed the advantages and disadvantages of such an alternative

CHAPTER 4
LABOR PRECAUTION

As the topic of the diploma thesis is devoted to the pressing issues of the reuse of solid waste in the construction industry, therefore, in the chapter on labor precaution it is necessary to investigate the impact of dangerous factors on a person during waste management.

4.1 Hygienic classification of labor

Labor protection is a system of legislative acts, socio-economic, organizational, technical, sanitary and hygienic and preventive measures and means that ensure the safety of health and efficiency of the person in the process of work.

Assessment of working conditions is carried out on the basis of "Hygienic classification production environment, severity and intensity of the work process.

Based on the principles of Hygienic classification, working conditions are distributed for 4 classes:

I - optimum working conditions - those conditions under which it is not stored not only the health of workers, but also the preconditions for support high level of efficiency.

II - acceptable working conditions - are characterized by the following levels factors of production environment and work process that do not exceed established hygiene standards for workplaces, and possible changes functional state of the body that are restored during the regulated period 7 rest or at the beginning of the next shift and do not exercise unfavorable impact on the health of workers and their offspring in the near and remote periods.

III - harmful working conditions - characterized by the presence of harmful

production factors that exceed hygienic standards and are capable to have an adverse effect on the organism of workers or its offspring.

IV - dangerous (extreme) - characterized by working conditions such levels of factors of the production environment that have a continuing impact a work shift (or part of it) poses a high risk of severe forms of acute professional defeats, poisonings, injuries, threat to life.

In the Table 4.1 harmful and dengerous factors of production is presented.

Table 4.1

List of harmful and dangerous factors of production

Name of factors	**Possible sources of their occurrence**	**Nature of action**
Risk of electric shock	Power supply	Dangerous
Fire hazard of premises	The presence of flammable materials and sources of ignition (electrical equipment)	Dangerous and harmful
Electromagnetic radiation including x-ray	The display is a source of X-ray, radio frequency, ultraviolet and infrared radiation and sound range radiation	Harmful

Static electricity	Dielectric surface of the screen	Harmful
Air ionization	Static electricity and X-rays	Harmful
Increased noise level	Noise is generated by the computer's voltage converter, its technical periphery, and by people in the audience	Harmful
Bad lighting	Insufficient artificial and natural lighting	Harmful
Poor microclimate parameters	Poor heating and ventilation	Harmful
Psychophysiological stresses	Monotonous work, overstrain of visual analyzers, mental tension, inconvenience and static poses	Harmful

4.2. Analysis of hazardous and harmful factors at the sorting station

The sorting station is an enclosed space where garbage cans are fed to the container, manual section and sorted.

Lighting and fume hoods must be provided at every workplace of the waste sorter. Some jobs may be redundant and used in the event of an increase in sorting line productivity. The quality control of recyclables and the presence of contaminants is carried out visually by the employees involved in sorting.

The employee is exposed to the following dangerous factors: chemical, physical and psychological.

Chemical:

- increased levels of sulfur gas, ammonia, methane in the work area and in the breathing zone;
- effects on the human body of hydrogen sulfide, chlorobenzene, mercury, soot, dust.

Physical:

- increased dustiness of work area air;
- emissions of odorless substances on waste sorting and composting lines;
- noise from vehicles and equipment for shredding waste;
- the influence of the magnetic field in the sorting of metal products;
- lack of light in the workplace.

Psychological:

- physical overload, static and dynamic stress;
- neuropsychiatric overload of visual analyzers;
- neuro-emotional overvoltage.

4.3. Hazardous factors the solid household waste impact on the person during exploitation of landfill

Organization of labor protection at household landfills waste is carried out in accordance with the Law of Ukraine "On Labor Protection" and provides for the implementation of measures aimed at preservation of life, health and efficiency of the person in the process labor activity [40].

The lack of an effective system for waste management at the state level causes accumulation a large number of them at the removal sites, to anthropogenic environmental load, pollution of its main components: land, water and atmospheric resources, deterioration living conditions of the population.

Hazardous wastes that have such physical, chemical, biological or other hazardous properties that creates or may present significant environmental and human health hazards and which require special methods and means of handling. Hazardous wastes contain substances that have hazardous properties - toxicity, explosion, fire, high reactivity, or contain infectious agents.

Hazardous waste is divided into 4 hazard classes:

Class I - extremely dangerous;

Class II - highly dangerous;

Class III - moderately dangerous;

Class IV - a little dangerous [41].

Household waste makes a significant contribution to environmental pollution. They are formed in the course of life and human activity wherever it is: in residential buildings, industrial enterprises, administrations, public organizations, non-productive institutions, medical, commercial and other institutions. It is the largest accumulation group in terms of volume of waste, which differs from all other waste in origin and composition. The specific difference between solid waste (MSW) is the great diversity and unpredictability of their composition. Due to the presence in the domestic solid waste of organic components (especially food waste) with high humidity, which are rapidly decaying and biodegradable, they are a source of unsanitary and environmental pollution of the environment. Solid household waste creates a sanitary and epidemiological risk due to unpleasant odors and harmful chemical compounds, which may be present or formed in the biological decomposition of organic components of waste and infectious and infectious agents.

The main method of waste disposal nowadays is to take them to a landfill with subsequent disposal.

The main dangerous factors of landfills are showed (fig. 4.1).

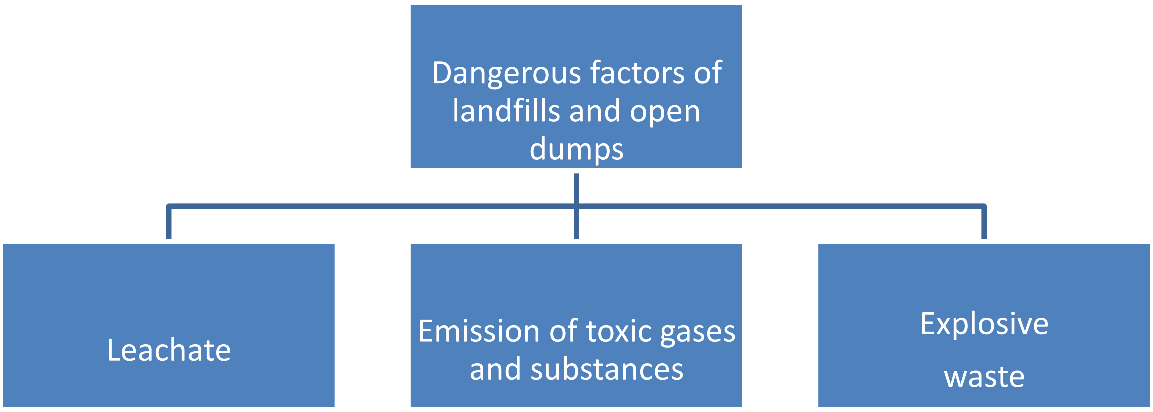


Fig.4.1. The main dangerous factors of landfills

Among the main professions at the landfill site you can identify the receiver checkpoint (hereinafter referred to as checkpoint), the planner and the bulldozer. The receiver monitors the arrival of the waste vehicle and the availability of the required documentation. The scheduler organizes the work of mechanisms and unloading of transport at the loading area. Bulldozers flatten and compact waste on working cards.

When interacting with MSW, the landfill worker is exposed to the following dangerous and harmful factors: chemical (phenol, formaldehyde, sulfur dioxide, hydrogen sulfide, carbon monoxide, nitrogen dioxide, etc.), physical: microclimate (increased or reduced ambient temperature, noise from transport, noise and equipment, biological (infectious and parasitic agents).

In order to prevent adverse effects on the health of workers of harmful and dangerous factors of the production environment workers of the landfill site must undergo mandatory preliminary and periodic medical examinations in accordance with the order of the Ministry of Health of Ukraine of May 21, 2007 No. 246 “On Approval of the Procedure for carrying out medical examinations of workers of certain categories”. In addition, MSW landfill workers should be provided with special clothing, special footwear and other personal protective equipment. Of great importance in the prevention of the adverse effects of harmful and dangerous factors of the working environment on the health of workers is the provision of their sanitary facilities (dressing rooms, showers, washrooms, toilets, rooms for eating, rooms for heating or cooling, etc.). In order to provide first aid in case of poor health or injuries, there must be a first aid kit with a supply of medicines and dressings at each site of the household waste site, which should be replenished periodically (depending on the shelf life of the medicines).

4.4. Conclusion to Chapter 4

So, in this chapter the negative influence of waste sorting on a person was investigated. The impact of toxic matters on a human was determined. Some measures for negative impact reducing of waste were proposed.

CONCLUSIONS

As a result of diploma paper development the scientifically and practical task to minimize the load on the environment was solved.

1. Waste accumulation in the World as a whole and in Ukraine was analyzed. Consider how much garbage is producing because of human activity. The low waste processing level was established.

2. Standard waste management methods were investigated. It deals mainly with the wastes that are infused in everyday life, such as: paper, plastic and glass bottles, car

tires. These are all recycling methods that will help humanity to properly treat waste and not dispose of it in landfills.

3. Several building technologies have been demonstrated. The simple technologies can be used for alternative materials production. for the conversion of plastic bottles into alternative replacement armatures was also proposed due to suggested technology.

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