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作品名稱 **CREATION AND RESEARCH OF
ECOLOGICAL MATERIALS AS AN
ALTERNATIVE TO SYNTHETIC
POLYMERS**

得獎獎項 二等獎

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關鍵詞 **disposable tableware and packages、
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organic raw materials**

作者照片



ABSTRACT

The research work is dedicated to analyzing the impact of disposable tableware and packages made from synthetic polymers on people and the environment, and the search for ecological alternatives to synthetic polymers used in their production.

Various types of disposable tableware and packages, their composition, production technology, harmful effects on the human body, environmental pollution, processing and recycling were studied.

The statistics of the use of disposable tableware and packages in Ukraine and the world as a whole, the places of their use were analyzed.

Ecological alternatives to disposable tableware and packages made from various natural materials have been studied.

A practical study of the use of organic waste and wastepaper for the production of ecological disposable dishes and packages was carried out.

Methods: analytical research (analysis contains data from international sites and conclusions of research held in foreign institutions), survey (which was hold among students of my school), and experimental research.

Keywords: disposable tableware and packages, ecological alternatives, waste, organic raw materials.

INTRODUCTION

The current topic for today is the quality of life, which is influenced by different factors. Since all factors are interconnected, looking for a solution to a big problem, it is necessary first of all to look for their cause in small things.

One of the global problems today is the pollution of the environment by household waste. Unfortunately, more and more preoccupied people think less and less about the consequences of their comfortable life. Every day more than 3.5 million tons of waste enter landfills. A large area of land is allocated for accumulation, a tradition that has been preserved there for centuries. This is not only an irrational use of land resources, and an economic disadvantage, but also a problem for future generations. According to USA Today in 2019, Ukraine ranked 9 th in the world in terms of the amount of garbage per inhabitant [1]. This is a problem that requires immediate action.

Among household waste, a large share is occupied by disposable tableware and packages used in food establishments, offices, during recreation, etc. The process of processing is a rather difficult technology. Over the past half-century, disposable tableware and packages have become very popular, especially during the pandemic. Now there is a large amount of plastic, paper packing, and food packing, and they have firmly entered our lives, because their use is convenient. The advantages of disposable dishes and packages and their lightness, ease of use, and low cost of production. But such convenience is accompanied by a number of problems, related to their disposal.

However, humans also come under the influence of disposable tableware and packages. Experiments show that microplastics can be found even in organ tissues. This work aims to study the harmful impact of disposable dishes and packages on human health and the environment, as well as the creation of ecological alternatives to synthetic polymers of materials.

SECTION 1

THEORETICAL PART

1.1. Industrial production and use of disposable tableware and packages

The world produces more than 300 million tons of plastic every year, half of which is intended for the manufacture of disposable products.

According to ScienceAdvances [2], as of 2015, factories produced about 6,300 million metric tons of plastic waste, 9% of which was recycled, 12% incinerated, and 79% accumulated in landfills. If current production and waste management trends continue, approximately 12,000 metric tons of plastic waste will end up in landfills or in the natural environment by 2050.

Therefore, plastic today is one of the most widespread and used materials used by humans, cheap and available.

Plastics or plastics are materials based on high-molecular compounds (polymers). Plastics based on synthetic polymers are extremely widely used. The production of synthetic plastics is based on reactions of polymerization, polycondensation, or polyaddition of low-molecular starting substances released from coal, oil, or natural gas, such as, for example, benzene, ethylene, phenol, acetylene, and other monomers. At the same time, individual high-molecular bonds with a larger number of starting molecules. This is a really complex and long process that takes place at specialized enterprises processing coal, oil, and gas [3].

Production begins with the extraction and transportation of oil and gas - raw materials for the production of plastic. This stage is accompanied by the release of toxic substances that enter the air and water in significant volumes (benzene, volatile organic compounds, and many others).

The processing of raw materials and the production of plastic are accompanied by the emission of carcinogenic and other highly toxic substances (benzene, and styrene) into the air.

According to Our Word in Data [4], China ranks first in the world in terms of plastic production. In Ukraine, this field of production is also developing rapidly. But in parallel with this, issues with the processing and disposal of used products must be resolved.

Among the manufactured products made of plastic, a large part is disposable tableware and packages, as they are used to store food products in restaurants, shops, homes, during recreation, and for lunch delivery. Various plastic, foil, and paper dishes are also often used.

Many countries around the world have begun to abandon non-ecological plastic packages. In Ukraine, the law limiting the use of plastic bags came into effect on December 10, 2021 [5]. This makes the topic of finding and applying ecological alternatives more relevant.

1.2. Types and characteristic of disposable tableware and packages

Types of disposable tableware and packages are determined depending on the material they are made from.

- Disposable plastic tableware.

There is information on all plastic products and what they are made from. It's a special marking for plastic. Such information appears as a graphic symbol, which reminds a triangle with a number from 1 to 7. This symbol is often seen at the bottom of the packages. Each symbol has a certain compound.

PET (polietylentereftalat) is mostly found on food containers for

prepared meals or drinks. PET's plastic influence can be harmful to health. According to the study, every drink that contacts with it captures the component whose composition is similar to estrogen. Avoid reusing items from PET. There is a number "01" on the marking.

HDPE (high-density polyethylene) is called out as a result of low pressure. Products from it are distinguished by increased strength and resistance to aggressive agents and acids. Packages can be reused safely. It is fully suitable for secondary processing. High quality, simplicity of formation, and relatively low production costs. Flower pots, containers, flasks, bottles, and dairy containers are most often made from plastic. Its symbol contains the number "02" in the middle.

LDPE (low-density polyethylene). It is made under high pressure. It is used in the manufacture of food containers and the pharmaceutical industry. It differs in a slightly lower degree of safety for our health than HDPE and PP. This is due to lower density. It is considered to be one of the two most harmless plastics. Packages can be reused several times. It is mostly used for the production of food film, foil grocery bags, packages for ketchup, and mustard. There is the number "04" in the middle of its symbol.

PP (polypropylene) is in the second place in safety after HDPE for keeping food products. It is not afraid of high temperatures. Therefore, it acts as a material for the production of plastic cups for serving hot drinks. Some of the examples where PP can be found are pots for yogurt, boxes for butter and margarine, and lids for cups. Plastic can be reused repeatedly. There is a number "05" in the center of the marking.

PS (polystyrene) is considered to be toxic. It should be avoided if possible. Disposable cups, lids, containers, and tableware have been made from it so far. The items have a marking with the number "06".

- Disposable paper dishes

There are 2 types of paper dishes: without coating and laminated. Laminated does not get wet for a long time, it is resistant to high temperatures. Its advantage is the low thermal conductivity of food and

drinks. They cool slowly. Therefore, the laminated paper needs special recycling.

- Bioware

Biodegradable tableware is tableware, which decomposes under certain conditions. Such cups, plates, and packages for food products are produced with special technology from natural materials – corn, sugar cane, bamboo, etc.

1.3. What is the harm of disposable dishes?

Plastic dishes are made of polymers. Before polymers were put into mass production, scientists spent many years studying their properties and effects on humans. Provided that all technologies are followed, this material is allowed to be used in the manufacture of disposable tableware. However, you should follow the instructions for using the dishes.

You need to be quite careful when using dishes made of polystyrene. Its surface should be marked as "PS". It is easy to distinguish: it is crispy and breaks. At a temperature of 60-80°C styrene can migrate from such dishes into the contents, from traces - up to 0.2 milligrams. If you use such a plate for a hot meal, you can also get a dose of toxins with it. Polypropylene dishes are used for hot drinks. It does not break, it just crumples and has a "PP" mark, or a triangle with the number five. Foam dishes are also used for hot dishes and drinks. It is inert, and therefore does not release toxic substances when in contact with food. A polypropylene cup can withstand temperatures up to 100°C. But if you drink alcoholic beverages from such a cup, your kidneys and eyes suffer.

Scientists conducted an experiment. Vodka was poured into a plastic cup. After a few minutes, scientists checked the composition of the contents. There was not vodka in the cup, but there was a chemical solution harmful to the body. You can avoid danger by analyzing the markings on the dishes [7].

An experiment was conducted at the Indian University of Haripur [8]. The researchers poured hot water, the temperature of which was 80-90°C, into paper cups. The liquid was in the cups for about 15 minutes, after which repeated studies were conducted on the change in the composition of the water. It turned out that microparticles of plastic and paper got into the clean water.

Usually, people spend 15 minutes drinking one cup of coffee or tea. This time is enough for 25,000 microplastic particles to get into 100 milliliters of water. They are so small that they can be absorbed in the digestive tract. Accordingly, they get into almost all organs of the human body.

Scientists from the Daegu Gyeongbuk Institute of Science and Technology conducted a study on mice to determine the effects of microplastics on the human body [9].

"The study shows that microplastics, especially microplastics 2 micrometers or smaller, begin to store in the brain even after short-term consumption within seven days, leading to apoptosis (programmed cell death), changes in immune responses, and inflammatory responses" says the study author Dr. Song-Kyun Choi.

Disposable tableware cause great damage to the environment, since almost all of them end up in landfills, only a small part is sent for recycling and requires special technologies to obtain suitable secondary raw materials.

1.4. Recycling of disposable tableware

Plastic plates, cups, and cutlery cannot be easily recycled at our recycling facilities. These items have the wrong shape or are too light to be properly sorted by recycling machines that are designed for separating large objects such as bottles.

Recycling machines often mistakenly sort plastic items as paper. Plastic products end up polluting paper and cardboard products and significantly degrade the quality of recycled paper products.

After being used for just a few minutes disposable tableware end up in the trash or worse as litter on our streets, parks, or landfills where it can remain for hundreds of years.

Paper towels, napkins, and plates are all paper products but they have never been recycled, because they are contaminated with food waste and fats. They should not be mixed during the recycling process with other clean paper waste, such as magazines and newspapers as this degrades the quality of the recycled material.

Paper cups do contain plastic. If they were completely paper, they would immediately get wet and the cups would be unusable.

Paper tableware is covered with a thin layer of film which prevents its processing. Separately, both paper and film can be recycled, but they complicate this task because the film must be separated before recycling. There is only one factory in Ukraine where this is done, the Zmiyiv Paper Factory in Kharkiv Oblast. It has been operating since 1893 and is currently the only enterprise recycling composite packages of its type Tetra Pak in Ukraine [10].

1.5. Ecological alternatives

- Corn starch tableware

Ecocorn creates tableware and packages based on corn starch [11].

The starch molecule is very similar in structure to the polypropylene molecule, and under certain conditions, the starch material surpasses the usual plastic in properties. Tableware made from this raw material is very pleasant to the touch, well preserves the taste, smell, and freshness of food. Hot drinks and alcohol can be poured into it – no harmful chemical reactions occur. In addition, the material is flexible and durable at the same time, hypoallergenic, and easy to use [12].

In production, corn starch with special substances of organic origin is put into the mixer. A liquid plastic mass is formed from it, which subsequently enters the drying chamber. After drying, the raw material

resembles a long canvas, which is transferred to the conveyor to the molding machines. The formation of dishes on the press machine takes place at a high temperature – 140-150°C. Formed tableware is removed from the matrix, cleaned, and cut off uneven edges.

Finished products are sterilized. Corn starch tableware decomposes in soil or compost in 18-24 months. It burns like paper - without soot and unpleasant smell.

- Bran tableware

The Polish company Biotrem [13] produces organic bran tableware. The company uses a technology that allows you to make disposable tableware from wheat and corn bran, as well as plant-based polymers. Raw materials are compressed under pressure with hot air.

The set of tableware includes plates, cups, forks, and knives. Such tableware is quite hard and durable. After use, such tableware becomes food for animals and birds. The manufacturer assures that bran plates are completely decomposed in 30 days.

- Bamboo tableware

Such tableware is hypoallergenic. The unique nature of bamboo makes it easy to cut, bend and shape it, presenting unlimited possibilities for making tableware that meets the most sophisticated needs of customers.

Bamboo tableware is very light and durable, resistant to scratches and chips. Even with a strong fall, it breaks without leaving sharp pieces, it is usually difficult to break it. It does not need special care, and does not absorb unpleasant odors. Bamboo tableware is not recommended for use in microwave ovens and washed in a dishwasher - this is its only drawback.

The production and use of bamboo tableware do not harm the environment. Bamboo grows extremely quickly - up to 50 centimeters per day, while it decomposes in 180 days. It has natural antibacterial properties, does not contain toxic substances, and is resistant to pests, so it does not need any chemical treatment before production.

- Paper from fallen leaves

Re-leaf PAPER [14] produces eco-friendly paper from fallen leaves. The production technology consists in turning fallen leaves into a solution from which cellulose is extracted and used for papermaking. Thanks to this method, two problems are solved at once: fallen leaves do not enter landfills, but become useful and it is not necessary to use wood for papermaking.

Now the company produces not only paper, but also products from it: containers for vegetables and fruits, paper bags, and egg holders [14].

- Organic waste packages

Italian designer Emma Siker has created eco-friendly packages from leftover fruits and vegetables [15]. She soaked the remains of vegetables and fruits in water, adding a symbiotic culture of bacteria and yeast, and sugar. Thanks to the fermentation, it was possible to obtain cellulose, from which a thick material was obtained during the drying process. From such a halftransparent material, Emma Secker created different types of tableware and packages.

Conclusion: The topic of environmental pollution by waste is very relevant. A huge part of the waste is disposable tableware and packages made from synthetic polymers. Their processing is a rather complicated process. Typically, such disposable tableware and packages end up in landfills, where over the years they decompose into microparticles of plastic that are difficult to assemble, so it pollutes the natural environment and water and the products we consume. Scientists have already proven the negative effects of microplastics on the human body. It is necessary to switch to ecological alternatives, so as to protect nature and people.

SECTION 2 SOCIOLOGICAL SURVEY

In order to investigate the actuality of the waste problem, I conducted a survey among students in grades 8-11.

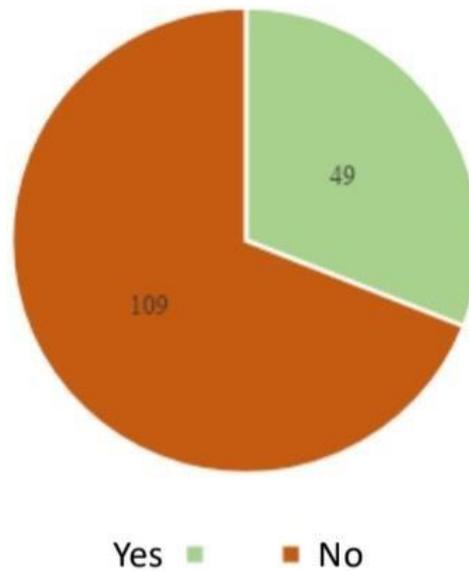
2.1. The questions of the sociological survey

1. Do you use disposable tableware?
2. Do you use eco-friendly disposable tableware?
3. Do you take food to school in disposable dishes?
4. Do you take water/drinks in disposable bottles/cups?
5. Would you use eco-friendly alternatives to disposable tableware and packages if they were more affordable?

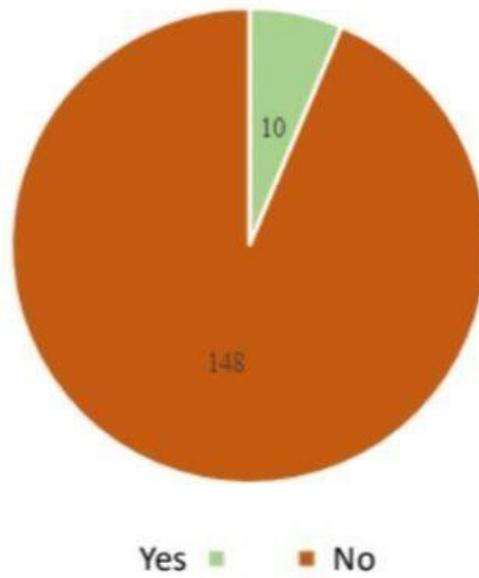
2.2. The results of the sociological survey

Students of 8-11th grades of the gymnasium took part in the survey. A total of 158 respondents were interviewed. The results of the survey are presented in the form of diagrams.

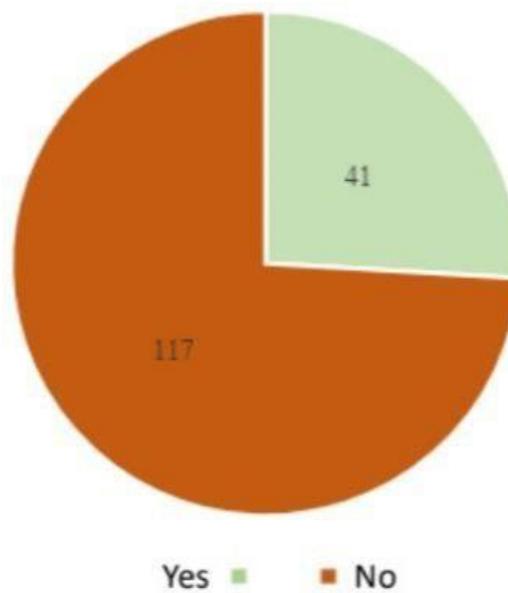
1) Do you use disposable tableware? Yes – 109, no – 49



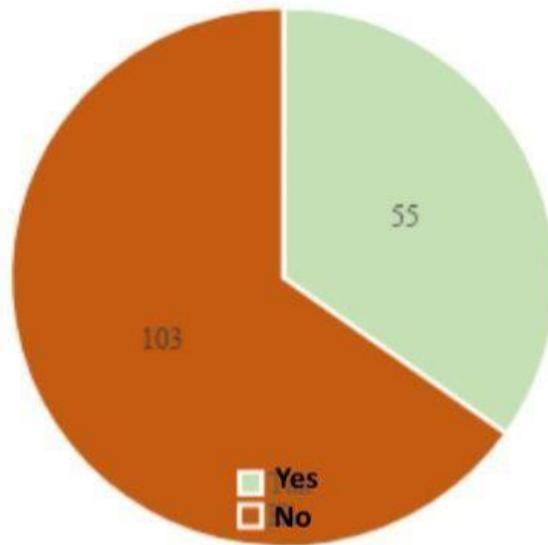
2) Do you use eco-friendly disposable tableware? Yes - 10, No – 148



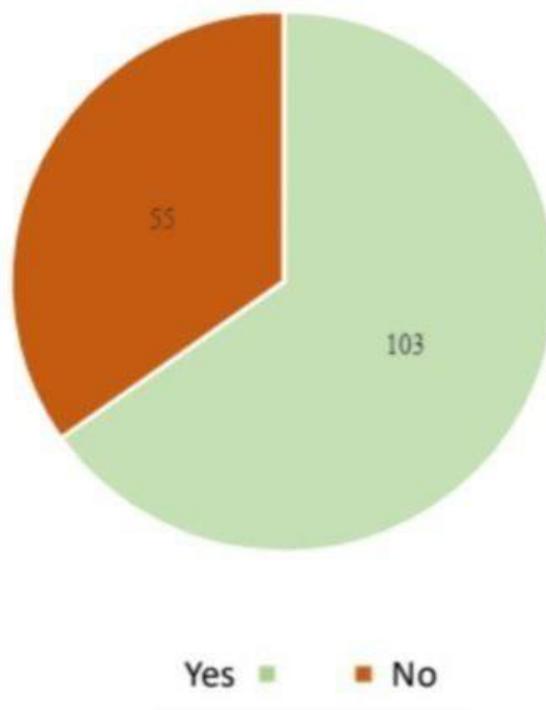
3) Do you take food to school in disposable dishes? Yes - 41, no - 117



4) Do you take water/drinks in disposable bottles/cups? Yes -55, no -103



5) Would you use eco-friendly alternatives if they were more affordable? Yes -103, no -55



Conclusions: So, a sociological survey showed that the majority of students use disposable tableware all the time and only a few of them use eco-friendly alternatives. It should be highlighted that students agree to use ecological alternatives, provided that such dishes are available. This indicates that the majority of students in the gymnasium are aware of the danger posed to the environment by the use of synthetic plastic, but are not ready to actively look for solutions. To solve this problem, it is necessary to make ecological disposable tableware more accessible, as well as to conduct activities to raise awareness among students about the environmental issues.

SECTION 3 PRACTICAL PART

3.1 Making paper from waste paper and organic waste

In practical work, 8 samples of ecological paper with various ecological fillers were produced and examined. For this, agricultural waste (straw, bean husks, sunflower and pumpkin seed shells, and waste paper were used (picture 3.1)

Experiment № 1

I set a goal to produce 8 types of paper with each type of organic waste. The first 4 samples were produced without the addition of starch, the second 4 samples were produced with the addition of starch. The prepared raw materials were poured with boiling water. After that, they were combined and crushed in a ratio of 50:50 (20 grams of organic waste and 20 grams of waste paper) with the addition of 80 milliliters of water. I put the resulting mass into a container with water and mixed it. With the help of a bandage braced on a frame, fished out the mixture, which created a thin layer on the bandage. After that, I turned the frame with the bandage (layer of the fished mass down) onto the cardboard and removed excess moisture with a sponge. The paper dried completely for a day. The results showed that the paper made with the addition of starch did not separate from the cardboard (pictures 3.2), and the paper made without the addition of starch was easily separated from the cardboard (pictures 3.3 – 3.6). The obtained paper samples, regardless of the filler, have a good appearance, and a pleasant texture, bend easily and are quite strong.

Experiment № 2

In the next study, I set the goal of testing the obtained paper samples for the rate of wetting. All 4 samples were placed in vessels with water at room temperature (picture 3.7). In 20 minutes, all samples were completely soaked but remained sticky (picture 3.8).

Conclusion: in the course of the research, 8 samples of paper were created and tested. 50% of each sample is organic waste, the other 50 % is secondary raw materials (waste paper). This makes paper production technology more ecological and cheaper because it does not require the use of wood. The paper is quite stable and esthetic. It can not be used for storing or packaging wet goods, because the resulting material soaked quickly under the influence of

water. Such paper can be used for the production of packages for dry food products and non-food products, packages for fruits and vegetables, creation of paper bags. Such material has prospects for mass use because the Verkhovna Rada agreed on a law limiting the usage of plastic bags on the territory of Ukraine, which came into effect on December 10, 2021.

3.2. Making pots from waste paper and organic waste

The next stage of our research was the production of pots from agricultural waste (straw, beans husks, sunflower and pumpkin seed shells) and waste paper. All organic waste samples were processed in a coffee grinder. After that, organic waste was mixed with waste paper in a ratio of 50:50 (40 grams of organic waste and 40 grams of waste paper) with the addition of 100 milliliters of water. I spread the resulting mass on the molds and left them to dry (pictures 3.9-3.10). For some pots, the molds were lined from the inside with bandages to make it easier to separate them from the mold in the future. In a few days, pots got dry and were removed from molds. They turned out to be quite strong. The samples, which were in forms without bandages, had a smooth surface from the outside and an esthetic appearance.

The pots were tested by planting seedlings inside (pictures 3.11). They have remained sticky for one week even with everyday watering, however, their quality decreased which can be noticed by the changes in their shapes.

Conclusion: In the course of the research, 5 samples of pots were created. 50% of their composition is organic waste, the other 50% is waste paper. The pots are stable and those which were made without using bandages have an esthetic appearance. This technology can be used to make ecological pots for seedlings. To improve their quality, and make them more stable, we have to apply the technology used in the production of paper cups with several layers of polyethylene. These layers can be replaced with ecological biodegradable films (for example cellulose triacetate, acrylic acid polymer, etc.).

CONCLUSIONS

The research work, which was carried out, showed:

1. Environmental-friendly packages can be made from waste paper and organic waste.
2. This method can be used for producing packages for goods, paper bags, cup holders, egg holders, and pots for seedlings.
3. The benefit of such material is its cheapness and environmental friendliness. Besides, this material consists of agricultural manufacturing wastes which are composted by the owners at best or are burnt at worst which is very harmful to the environment.
4. I have produced environmentally friendly pots and I planted seedlings into them. Such pots with a certain amount of minerals and plant protection agents added to their composition can be an alternative to more expensive pots made of peat, which are used to plant seedlings. In order to make them more sticky, adding an inside biodegradable film is required. That might help improve the waterproof level and make them more convenient for usage.

LIST OF USED INFORMATION SOURCES

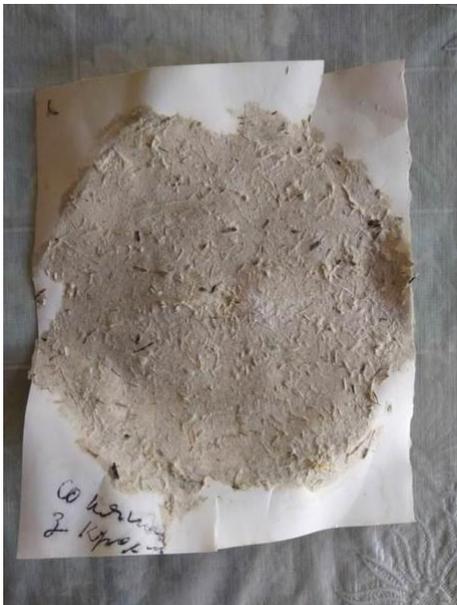
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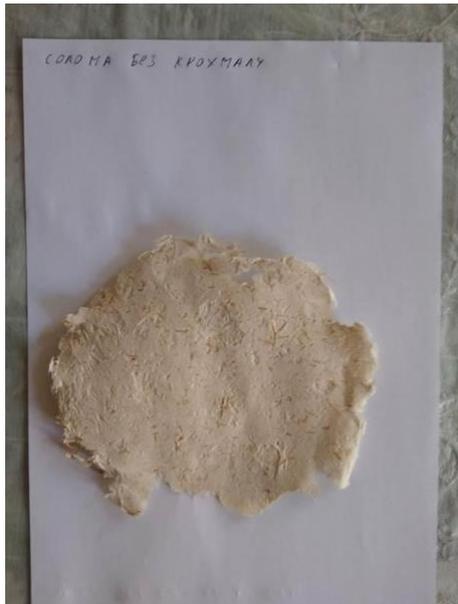
APPENDIX



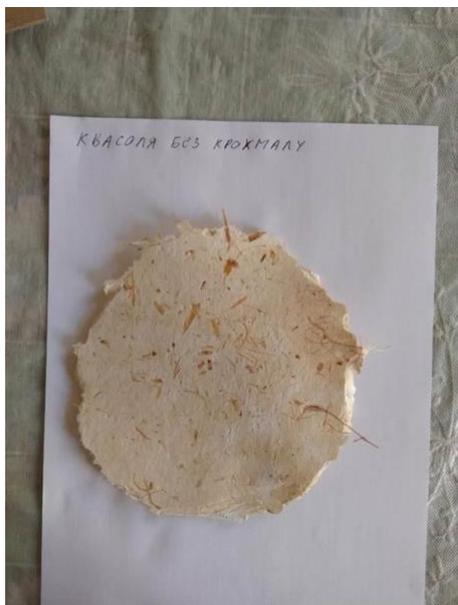
Picture 3.1* Samples of raw materials for research – agricultural waste (straw, bean husks, sunflower and pumpkin seed shells), waste paper and starch



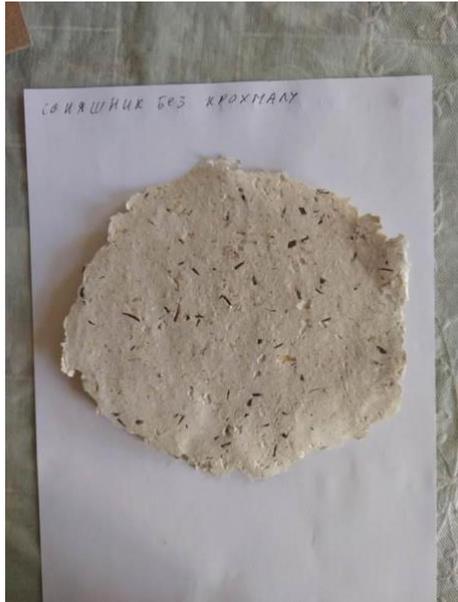
Picture 3.2* Paper which was made with the addition of sunflower seed shells and starch



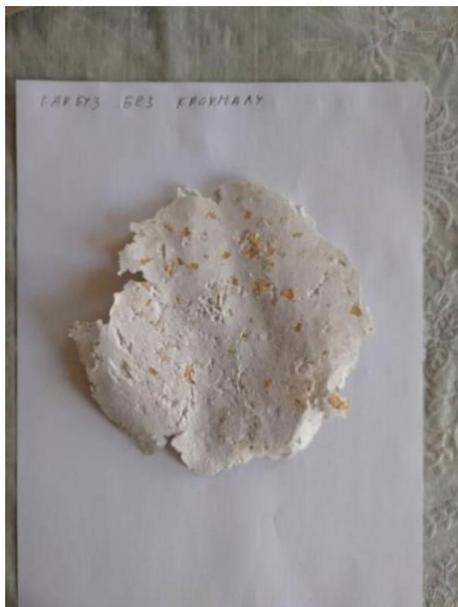
Picture 3.3* Paper which was made with the addition of pumpkin seed shells without starch



Picture 3.4* Paper which was made with the addition of bean husks without starch



Picture 3.5* Paper which was made with the addition of sunflower seed shells without starch



Picture 3.6* Paper which was made with the addition of pumkin seed shells without starch



Picture 3.7* Samples of paper were placed in water at temperature approximately equal to 20° C



8

Picture 3.8* Samples of paper after 20 minuts spent in water



Picture 3.9* The resulting mass spreaded on the molds



Picture 3.10* The ready pots. View from the side. The top line of pots were made without using cheesecloth, the bottom line of pots were made with using bandage



Picture 3.11* The pots with seedlings

* All pictures belong to the author of the research

【評語】 200020

The research topic is important and follows the concept of circular economy. It is recommended to measure the mechanical strength of the tablewares made of ecological materials for real application.