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Geoecological analysis of impacts of the use of plastic waste in road construction on the geological environment

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Abstract. Currently, society and industry are developing at a rapid pace, and an increasingly serious problem of the modern world is environmental pollution, requiring recycling and reuse wastes. Modern technologies in the field of road construction involve the use of polymeric materials obtained from waste recycling. Almost nothing is known about soil contamination by plastic in general and the destruction of roads in particular; probably because of lack of awareness and absence of standard methods for quantifying plastic components in soil. The contemporary data suggest that flow of plastic has already reached a value similar to that found for other contaminants, such as heavy metals. In particular, migration is observed for plastic microparticles, but so far, their effect on groundwater has not been studied. Therefore, additional research is urgently needed to shed more light on the fate and impact of these persistent materials in the terrestrial environment. The purpose of the study was a geoecological analysis of the risks of using polymer waste in construction of roads to the geological environment. To ensure environmental safety in the implementation of technologies for the utilization of polymer waste, it is necessary to take into account their chemical composition, the ability to form hazardous products in increasing temperature, hazard class, physical and chemical properties. We propose criteria for assessing the possibility of recycling polymer waste in road construction, namely for the manufacture of asphalt concrete. According to the proposed overall criterion, taking into account not only technical and economic indicators, but also the environmental component, we can recommend the use of HDPE and LDPE, as well as PP for use in road construction. Taking into account the total criterion, we recommend using HDPE, LDPE as the most acceptable waste for road construction,, as well as PP. The technological scheme should include the collection, sorting of these plastics, as those that do not contain hazardous chemicals. Temperature conditions for manufacturing asphalt involve heating and converting the components into the liquid phase for uniform mixing of the entire composite. Under those temperature conditions, chemical compounds that are harmful to the environment and humans would not be created. The possibility to substitute part of the bitumen, to obtain asphalt concrete with high performance, increased service life shows the cost-effectiveness of using these groups of polymer waste in the technology of manufacturing asphalt concrete. The lack of regulatory framework and technical standards for working with polymers for paving brings the problem of plastic roads to the legislative level.

Key words: polymer waste, migration of microplastics, heavy metals, environmental criterion.

Геоекологічний аналіз небезпеки використання пластикових відходів у геологічному середовищі при будівництві доріг

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Анотація. В даний час суспільство і промисловість розвиваються бурхливими темпами, і все більше серйозною проблемою сучасного світу стає забруднення навколишнього середовища, переробка відходів і їх повторне використання. Сучасні технології в галузі будівництва автомобільних доріг припускають використання полімерних матеріалів, отриманих при переробці відходів. Наразі майже нічого не відомо про забруднення ґрунту полімерами взагалі і при руйнуванні дорожнього полотна конкретно; імовірно, тому, що обізнаності не достатньо і немає стандартних методів для кількісної оцінки компонентів пластику в ґрунті. Поточні дані свідчать про те, що потоки пластику вже досягли величини, подібної до тієї, що виявляється для інших забруднювачів, наприклад, важкі метали. Міграція особливо спостерігається для мікрочастинок пластику, але їх влив на ґрунтові води ще майже не вивчений. Тому терміново потрібні додаткові дослідження, щоб краще висвітлити долю та вплив цих стійких матеріалів у наземному середовищі. Метою дослідження є геоекологічний аналіз небезпеки використання полімерних відходів у геологічному середовищі при будівництві автомобільних доріг. Для забезпечення екологічної безпеки при реалізації технологій утилізації полімерних відходів необхідно брати до уваги їх хімічний склад, можливість утворювати небезпечні продукти при підвищенні температури, клас небезпеки, фізичні і хімічні властивості. Запропоновано критерії для оцінки можливості утилізації полімерних відходів у будівництві автомобільних доріг, а саме для виготовлення асфальтобетонного покриття. За запропонованим сумарним критерієм з врахуванням не тільки техніко-економічних показників, а й екологічної складової можна рекомендувати використання ПНТ та ПВТ, також ПП для утилізації у дорожньому будівництві. Враховуючи сумарний критерій пропонуються до технології будівництва автомобільної дороги використання ПНТ, ПВТ як найбільш прийнятних відходів, а також ПП. Технологічна схема повинна включати збір, відсортування даних пластиків, як таких, що не містять небезпечні хімічні речовини. Температурні умови отримання асфальтового покриття передбачають нагрівання і переведення компонентів у рідку фазу для рівномірного перемішування усієї суміші. У даних температурних умовах не будуть створюватися хімічні сполуки небезпечні для навколишнього середовища і людини. Можливість замістити частину бітуму, отримати асфальтобетон з підвищеними експлуатаційними показниками, збільшеним терміном служби показує економічність використання даних груп відходів полімерів в технологіях отримання асфальтобетону. Відсутність нормативної бази та технічних стандартів по роботі з полімерами для дорожнього покриття виводить проблему пластикових доріг на законодавчий рівень.

Ключові слова: полімерні відходи, міграція мікропластику, важкі метали, критерій екологічності.

Introduction.

Because of increase in the amount of plastic and other polymeric wastes, and also problems they cause to the ecosystem, those source of pollution need to be urgently controlled. Many products of plastic breakdown are toxic when introduced into soil or water, cause negative impact on the environment and human health. Rates of accumulation of plastic wastes are astonishing (Fig. 1).

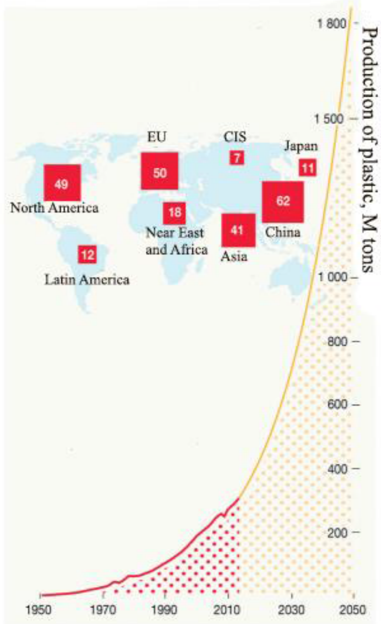

Fig. 1. Global production of plastic and prediction for 2050 (Ryan, 2015)

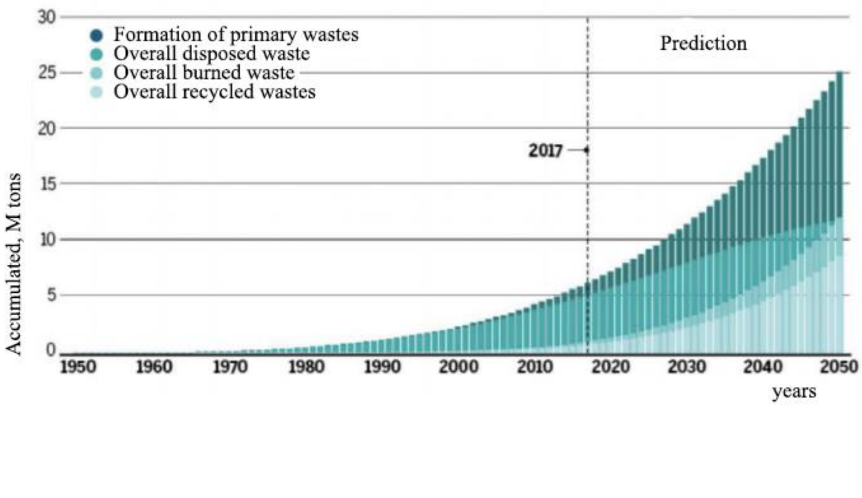

Fig. 2. Rates of accumulation of plastic wastes and prediction for 2050 (Geyer, 2017)

There are 3 main ways of managing plastic wastes. First of all, it is recycling into secondary material. This results in plastics with limited or low material value. In 2015, less than 10% of accumulated wastes were recycled. Secondly, plastics are destroyed thermally. Around 12% of plastics are incinerated (Geyer, 2017). Effects of waste-to-energy plants on the ecosystem and humans are determined by technologies of emission control. The third way is burying in landfills. Natural factors (wind, precipitations, sun) ruin plastic gradually, leading to environmental contamination, first of all to such of geologic environment (soils, surface water and groundwater, etc).

At the International level, the issue of plastic wastes is regulated by global conventions on chemical substances and wastes: the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, the Stockholm Convention on Persistent Organic Pollutants. Nonetheless, those issues have not been served as of now, and are becoming more complicated each year.

Polymers are characterized by high resistibility to the effects of aggressive chemical environments. However, they undergo destruction as well, contaminating geosphere surfaces, indicating low effectiveness of burying polymer products. Plastics are also known to contain heavy metals (HM), dioxins, furan, mercury, polychlorinated diphenyl, halogens, etc (Hodson, 2017, Mason, 2018).

A new promising method of utilizing plastic wastes seems to be recycling them for use in construction, particularly road construction. Development of road surfaces that would satisfy modern exploitation and technical requirements is currently underway. Such solutions include development of surfaces using polymeric plastic materials as components. Obtaining bitumen-plastic composites is a promising direction. Wastes of thermoplasts are introduced into asphalt-concrete mix in melted state. Mixing wastes with bitumen, mineral oil and fillers results in highly strong road surfaces. However, study of ecologic requirements to road construction using plastics has not been considered broadly in the scientific literature.

The technology of road construction using plastic was for the first time patented in the Netherlands. In 2015, the KWC Company used recycled plastic to build long-durable and cheap roads. During the tests, the bearing capacity of such a surface was no lower than such of asphalt concrete. Furthermore, the new material is characterized by higher exploitation characteristics, parameters of solidity and carrying ability. However, no ecologic studies have been performed (Lysyannikov, 2017). This technology has become popular in the Netherlands, Germany, France, Italy, Japan and India.

Plastic wastes are processed, mixed with modifiers and bitumen, which allows obtaining road surfaces that are characterized by regulated water penetrability, high firmness, long durability and reliability compared with asphalt concrete created using the traditional technology. The advantage of «plastic» asphalt is also significant decrease in energy expenditures for its production, since it can be produced in lower temperature. Cost of construction of «plastic» road is insignificantly (3% on average) higher compared with asphalt concrete (Lukashevich, 2020). However, this is offset when taking into account longer durability, simplicity of repair and maintenance, and decrease in greenhouse gas emissions. Currently, construction of roads with addition of polymer plastic is more expensive than the regular method, but with increase in amounts of use, the cost of such roads would definitely decrease. The main goal of this technology is utilizing large landfills for making effective and safe road-construction material.

Share of modified roads containing polymer materials accounts for 15% in the USA and China, and 20% in Europe (Fig. 3). In Ukraine, the share of the use of modified bitumen in road construction is 1-5% according to various data. One of the main causes of such low parameter is extremely high cost of modifiers, which are mainly imported goods (Gritsenko, 2016).

Such technologies in road construction are slowly conquering the market. However, longer tests of their exploitation are needed, and a number of surfaces' characteristics, first of all ecologic, need to be clarified.

However, an important question arises whether roads made using plastic are a geochemical barrier for toxic components of construction materials, preventing them from entering the geologic environment (groundwater and soil).

In this study, we attempted to analyze the danger of using polymeric wastes in the geologic environment from the perspective of geoecological analysis. Interest to this problem is due to large scales of road construction, on one hand, which require increasing amount of road-construction materials, and necessity to solve the problem of utilization of polymeric materials, on the other hand (Shubov, 2019, Lukashevich, 2020). MacRebur Company tested alkalinization of chemicals from a piece of road plastic in the laboratory conditions, but only for 18 h (MacRebur, 2020), coming to a conclusion that plastic roads are ecologically safe for many years of road exploitation.

On the other hand, some researchers are strongly against new method of constructing roads using plas-

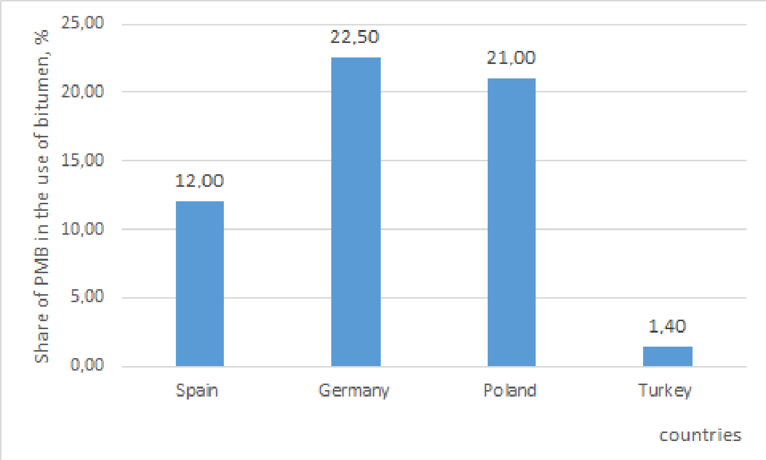

Fig. 3. Share of use of polymer-modified bitumen in the overall use of bitumens.

tic. For example, (Conlon, K., 2021) thinks that the asphalt-paving of roads using plastic is an ecologic catastrophe, leaving the problem of responsibility for prolongation of formation of plastic wastes open.

Therefore, there is an opposite opinion about ecological safety of using plastic in road construction (Provatorova, 2021). No doubt this solves the issue of utilization of wastes, but no evidences of safety of such a technology have been provided.

The objective of the research.

The objective of the research was geoecological analysis of risks the use of polymer wastes in road construction constitutes to the geoecologic environment.

To achieve the goal, we performed:

- analysis and systematization of scientific data on potential threat to geological environment posed by plastic that has been used in road construction.

- we distinguished and assessed criteria of possibility of utilization of various types of plastic for road building.

-Analyzed the impact of migration of hazardous polymer components to geological environment;

-Selection of technologies that are promising from the ecological perspective.

Materials and methods of research

The paper demonstrates the level to which the scientific issue has been studied, provides a critical evaluation of researches published on the topic. Theoretic positions were formulated based on geoeconomical analysis, and also physical and organic chemistry.

We suggest the method including determining criteria of evaluation of utilization of polymer wastes in road building. Overall criterion includes assessment of design for manufacturability, cost effectiveness and nature-friendliness of the suggested technique of utilization.

Results and their analysis.

To provide ecological safety during realization of technologies of utilization of polymer wastes, one should take into account their chemical composition, possibility of formation of hazardous compounds during temperature rise, danger class, physical properties, for example, melting temperature.

No less important aspect is the problem of migration of hazardous chemical substances (particularly heavy metals) to geological environment.

Physical-chemical properties of polymers are grouped in Table 1.

To select polymer wastes, a number of criteria are proposed:

-technological criteria that determine a possibility (convenience, availability) of using the corresponding technology of utilization of polymer wastes in road construction, convenience of sorting polymer wastes; scales of formation and accumulation of this type of wastes; necessity of prior preparation, processing (sorting, shredding); best conditions for provision of quality of technological process;

-Economical criteria that determine profitability of using the respective technology;

-Ecological criteria take into account the risk of contamination of the environment (first of all of geological environment) and impact of hazardous chemical substances on humans and the entire ecosystem.

The use of polymer wastes in road building is currently highly promising from the perspective of plastic utilization. However, the technology of making asphalt concrete involves its heating up to the temperature of 190-200 ^{o}C. In such a temperature, chemical transformations may occur in the structure of polymers, releasing hazardous products of the reaction.

The proposed criteria were used to evaluate the possibilities of utilization of polymer wastes in road construction, and also to produce asphalt-concrete surface (Table 2). According to each criterion, polymer waste was assigned 1 to 3 point. Collectively, the authors had a long discussion, suggesting various approaches to giving the points. Ultimately, we proposed our own method, described in this paper. The authors suggested such an approach that may be further extended and substantiated based on the perspective of scientific methodology in one of the future articles.

To use polyethylene terephthalate (PET), PET plastic bottles are collected, sorted from the overall flow of solid municipal wastes. After removal of the labels, caps and rings, the bottles are pressed and shredded to 5 mm size (Moldakhmetova, 2021). This type of plastic is the commonest. The material is recyclable and is one of the most dangerous types. It has increased firmness, stiffness and thermal tolerance. However, there are data revealing dangers of using it in manufacturing asphalt concrete (Moskovets, 2016). Polyethylene terephthalate is known for containing heavy metals (for example, antimony) and carcinogens. Those substances are released in high temperature and melting.

The study by Bilotserkovska O.S. points out to such an important disadvantage of using plastic in road building as release of hazardous substances in high temperature (Belotserkovskaya, 2020).

Table 1. Physical-chemical and ecological properties of polymeric wastes that are used in road construction

Polymeric wastes	Formula	Use	T of melting, °C	Density, g/cm^3	Ultimate tensile strength, UTS	Danger class	Impact on the environment
PET 01 PET	$(C_{10}H_8O_4)_n$	Bottles of water, gassed water	255-265	1.36-1.46	172	V	Can produce toxic substances: phthalate and heavy metals (Mason, 2018)
HDPE 02 PE-HD	$(C_2H_4)_n$	Packing for household chemicals	125-140	0.91-0.95	18-32	V	Practically untoxic
PVC 03 PVC	$(C_2H_3Cl)_n$	Stretch film for food, hoses, stretch ceilings	150-220	1.35-1.43	40-50	IV	One of the most poisonous types of plastic
LDPE 04 PE-LD	$(C_2H_4)_n$	Garbage bags, toys, food packaging	102-132	0.90-0.93	7-16	V	Practically untoxic
PP 05 PP	$(C_3H_6)_n$	Food containers, syringes	160-170	0.90-0.92	245-392	V	Considered safe
PS 06 PS	$(C_8H_8)_n$	Disposable tableware, polystyrene	170-240	1.05	39,2-44	V	Produces styrene (carcinogen)

In high temperature and when burned, polyvinyl chloride (PVC) emits dangerous carcinogenous dioxins, and also lead and cadmium – the most hazardous heavy metals – into the air (Buts, 2019, Buts, 2020). Even when heated insignificantly, PVC generates vinyl chloride, dioxins and other toxic compounds present in the additives (stabilizers, oils, plastifiers, fillers) used for PVC production. Use of PVC for making asphalt concrete shall lead to poisoning of the environment and pollution of the geological environment, particularly sources of water. Polymer has elastic structure. When burned, it gives off a sharp odor of smoke, soot.

Table 2. Criteria of evaluation of utilization of polymeric wastes in road construction

Polymeric wastes/criteria	Design for manufacturability	Cost effectiveness	Nature-friendliness
PET	1	1	2
HDPE	3	3	3
PVC	2	2	1
LDPE	3	3	3
PP	2	2	3
PS	1	2	1

Polyethylene of low pressure (HDPE) has a weak structure, is stiffer than low-density polyethylene. Low-density polyethylene (LDPE) is well recyclable and good for reuse. From the ecological standpoint, HPDE and LDPE are quite safe plastics to use. Nonetheless, there are data that LDPE has a low parameter of firmness threshold during rupture and produces formaldehyde (Andruhova, 2020). Compared with previous polymers, polypropylene (PP) is thermo-resistant, solid and relatively safe.

When heated, polystyrene (PS) exudes the most hazardous poison and carcinogen – sterol.

After long period of use, polystyrene (PS), starts producing bisphenol, it is the material with high firmness to extension and ruptures, bears great mechanic loads, but quickly breaks after having deformations.

Plastic wastes can also contain various additives: stabilizers, colorings, plastifiers, special additives that contain heavy metals – cadmium, lead, mercury. Heating of such wastes may cause influx of heavy metals (HM) into the environment, including geological environment during road building.

When manufactured at plant, the temperature of hot asphalt equals 100-180°C and the mixture's temperature during storage is below 190°C, and therefore for plastics added to the mixture, the temperature of softening and melting should be within those borders. The composite is prepared right before application on road-building site, because bitumen-polymer mix with plastifiers added is not supposed to be stored for long. Over time, the mix breaks down to bitumen and polymers, becomes inappropriate for use, also posing a great threat to surface layers of soil.

Exposed to daylight, road surface can heat up to over 70°C.

Thus, the technology of utilization of plastics in road building, with the use of material resources of plastics, with cycle of obtaining asphalt concretes requires significant additional geoecological analysis.

«Benefit» of using plastic in road building is doubtful from the perspective of impact on the geological environment in the future (first of all, migration of hazardous chemical substances to soils and groundwater). Therefore, using plastic wastes endangers the ecosystem in general.

In general, technological utilization of polymer wastes in road construction would likely have a positive economic effect in the long run as a result of increase in road exploitation period, decrease in cost for repairs, and decrease in costs for storing plastic wastes. However, production of asphalt with addition of plastic is currently 13% more expensive than the regular asphalt (Masood, 2021).

In general, it is hard to predict the ecological effect the use of plastic wastes in road construction would have on the nature protection measures. It requires geoeconomic, chemical, physical-chemical analyses, and complex evaluation by scientists of different spheres (ecologists, geologists, geochemists, geographers, soil scientists, etc) rather than just motivation by yet unconfirmed economic effect.

Absence of legal basis and technical standards for the use of polymers for laying roads does not solve the problem of plastic roads at the legislative level.

There is an opinion (Andruhova, 2020) that optimal raw materials for obtaining light and strong polymer asphalt concrete are:

1. PET – polyethylene terephthalate;
2. PP – polypropylene.

Pugina V.K. and co-authors (Pugina, 2021) recommend HDPE and LDPE. Those plastics are quite strong and elastic, able to maintain their properties of firmness during deformation, and temperature regimes are most optimal to solve the issue. But are they «hundred percent» safe for the environment, particularly geological environment?

According to the overall criterion, taking into account not only technologic-economic parameters, but also geoecological component, one can recommend using HDPE and LDPE, as well as PP, for utilization in road building (Fig. 4).

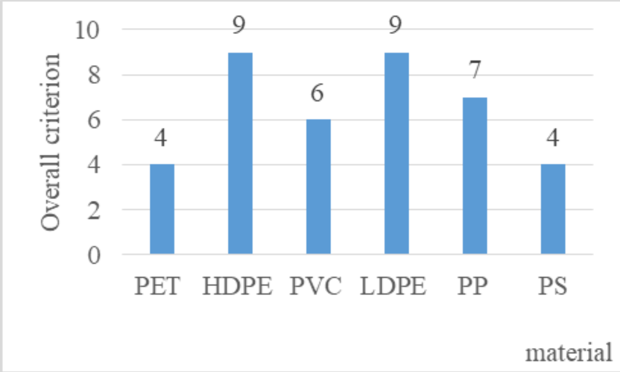

Fig. 4. Overall criterion of evaluation of utilization of polymeric wastes in road building

Over the recent 5-7 years, the interest to the notion of microplastic has sharply increased due to discovery of it in all components of the ecosystem (Mason, 2018; Schwabl, 2019).

Using methodological modeling, Ryberg (2019) estimated that approximately 3, 0 M T of microplastic was introduced into the environment in 2015. The main sources were abrasion of rubber tires, erasure of road marking and plastic, which promote formation of city dust. At the same time, wear out of the road surface that contains plastic wastes has not even been analyzed so far. Plastic enters soil through various ways, in particular as a result of degradation of road surface (Blasing, 2018). Kim et al. (Kim, 2006) found that a large portion of junk washed off roads during storms is composed of substances that do not decompose, such as plastic, with litter load equaling 0.85 to 6.6 kg/ha.

Microplastic has contaminated groundwater (Voronova, 2019). It was found in 16 of 17 samples of water, the concentration equaled 6.4 to 15.2 microparticles per liter. Those particles soak up contaminants like sponges. Up to 430 thou T of microparticles are annually introduced into soils in Europe, and 300 thou T in North America (Voronova, 2019).

The source of microplastic that enters soils can be road runoff (Blasing, 2018).

There are data on content of microplastic in soil. Its presence was confirmed to be associated with roads and paints for marking which have not been used before (Horton, 2017). The microplastic particles were determined to be related with pigment that is usually added to thermoplastic paints for road marking.

Dust from tires abrasion, ruination of plastic-containing road surface, not only accumulates in road ambience, but also migrates to surface water objects and even marine ecosystems. As a result, abrasion of tires was recognized as a serious source of microplastic (Ryberg, 2018). Ryberg M.W. (2019) estimated that ruination of road marking alone annually causes contamination equaling 0.59·106 T of microplastic particles into the environment. Therefore, we should assume that ruination of road surface made using plastic wastes would be accompanied by geochemical migration of microplastic.

Road works were named third by scales (7%) of source of formation of microplastic after synthetic textile materials (35% of the overall introduction of microplastic into the ecosystem) and car tires (28%) (Nekhin, 2021). The report considers only the use of plastics for road marking is considered. Using it in road construction would increase the share of formation of microplastic particles from wear out of road surface by multiple times.

Special threat of microplastic is related to the fact that it easily inters living organisms. This is extremely dangerous considering how harmful they are for animals and plants and humans as an element of the food chain. There were reports suggesting possibility of accumulation of microplastic in soil (Chai, 2020), and possible accumulation in living organisms (Dowarah, 2020).

Microplastics are found in almost all elements of the ecosystem, and likewise microplastics particles are being found in human organism, mostly identified as PP and PET (Ragusa, 2021). Microplastics could be associated with many unfavorable effects, because those particles can sorb various toxic components solved in water, becoming centers of their aggregations (Fig. 5).

Danger posed by microplastics is related to toxic fillers they contain. Such additives can account for 4% of the massive share (Voronova, 2019). They perform functions of plastifiers (phthalates), modifiers, flame inhibitors, biocides, antistatic agents, thermostabilizers (alkylphenols) and antioxidants, colorings, lubricants, photostabilizers. Many of them are substances the toxicity of which has been confirmed, particularly stable organic contaminants (polychlorinated biphenyls, polycyclic organic carbohydrates, phthalates and others), inorganic compounds (titan dioxide, barium dioxide and others), and also monomer residuals.

Microplastic can adsorb HM and hydrophobic organic contaminants. Adsorption of organic contaminants by microplastics involves surface adsorption and filling of the pores of polymer structures (Hodson, 2017). Because microplastic, similarly to many organic contaminants, has hydrophobic properties, it is able to be easily adsorbed by soil particles (Fig. 5) and oranic compounds (Horton, 2017).

The study of Hodson M.E (2017) analyzed adsorption of Zn^{2+} on the surface of microplastic, revealing that this results in better bioavailability of zinc ions. Large particles of microplastic can adsorb many HMs (Lu, 2019). Particles of microplastic sorb organic contaminants and HMs, promoting increased local concentrations of pollutants (Fig. 5).

Hodson et al. (2017) noted high adsorbing potential of plastics as carriers as well. This function increases absorption of HM from soil moisture. Depending on chemical and physical properties of material (specific surface and molecular polarity), rates of HM adsorption by microplastic can significantly vary (Teuten, 2007). Studies revealed that Cd and Pb concentrations in plastics equaled 6.9 % and 7.5% respectively, indicating different rates of adsorption and degree of affinity to microplastic.

Presence of microplastic in soil hinders absorption of water and nutrients by root system of plants (Fig 5). De Souza Machado et al. (2017) demonstrated that soil microplastic can significantly alter biomass of plants, chemical composition of the tissues, morphology of roots and microbiological activity of soil.

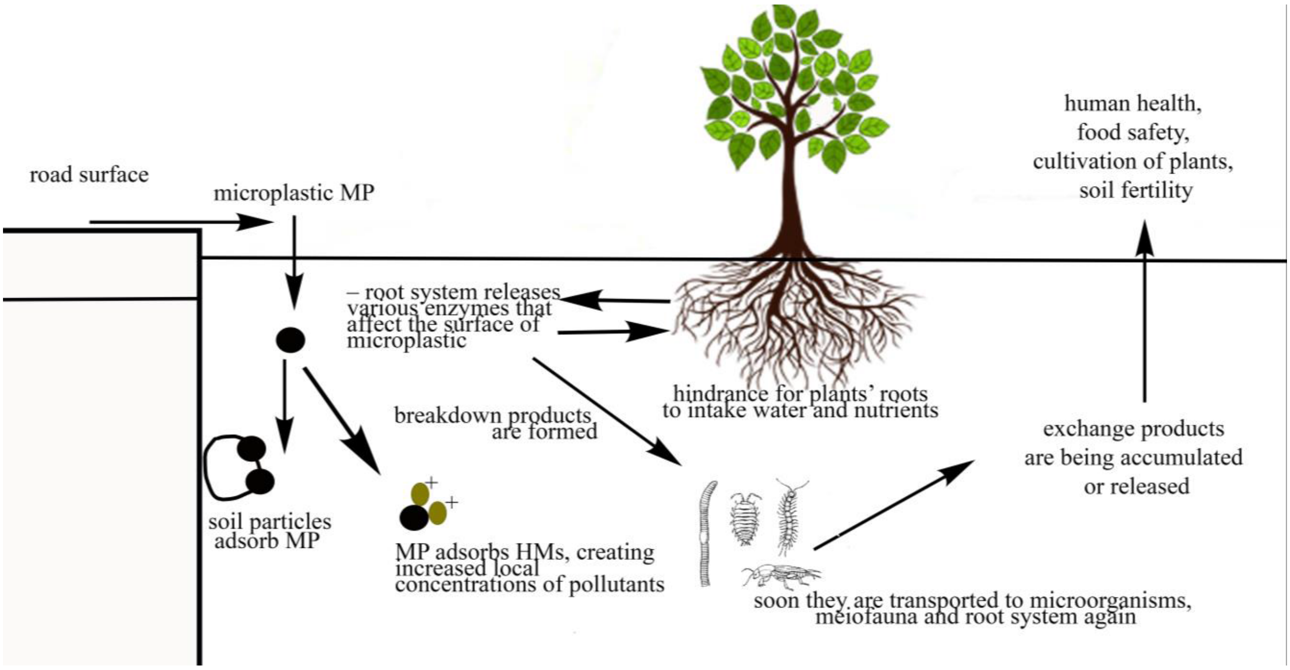

Fig. 5. Scheme of interaction between microplastic and soil microorganisms, animals and plants (charted by the authors)

The effects of microplastic on soil biota are still being debated due to absence of knowledge of influence of microplastic on representatives of various taxonomic groups.

The studies by E. Huerta Lwanga et al. (2017) revealed that microplastic poses a serious threat to soil biota by hindering growth, reproduction of organisms, and decreases soil biodiversity. We may assume that study of effects of microplastic of various origins on soil biota requires integrated research of chemical processes of sorption and desorption of organic and inorganic pollutants by microplastic.

Microplastic can be accumulated by earthworms (Gaylor, 2013) and even take toxic effects (Huerta Lwanga, 2016). Microplastic can affect vitality, growth, reproduction, histopathology and immune system of earthworms (Huerta Lwanga, 2016).

There are data about accumulation of microplastic in yeasts and mycelia fungi (Chae, 2018). Studies demonstrated toxicity of nanoplastics for a number of mycelia fungi (Nomura, 2016).

However, technological scheme should include collecting and sorting out plastics that contain no hazardous chemical substances. Temperature conditions of obtaining asphalt surface include heating and conversion of components into liquid phase the entire composite to be evenly mixed. In such temperature conditions, no chemical compounds that would pose threat to the environment and people must be formed.

Another disadvantage of utilization of plastic in road building is that the technology is not yet time-tested. Developers are confident that expected exploitation period of plastic roads is approximately 30 years, though no confirmation has been received so far (Mir, 2015). Also, it is unknown what ecological consequences would there be for the environment in the future.

Plastic roads are no doubt helping in utilization of old plastic, but the complex effect of the roads themselves is yet to study.

Conclusions.

The research revealed the level to which the scientific problem of danger to geoecological environment from plastic wastes during road construction has been studied, and critical evaluation was given. Theoretical positions were formulated based on geoecological analysis, and also physical and organic chemistry.

We proposed the method of determining criteria to evaluate the utilization of polymer wastes in road building. The overall criterion includes evaluation of technological, economical and ecological aspects of the proposed way of utilization. According to the suggested overall criterion, taking into account also the geoecological component, we can recommend using HPDE and LDPE, and also PP, for utilization in road construction. The overall criterion for those plastics was the highest, equaling 7-9 points.

The research analyzed data on possible effects of microplastics on soil, we made a scheme of interaction between microplastic and soil microorganisms, animals and plants. Also, further studies of effects the microplastic takes on representatives of various taxonomic groups are also needed.

There is not enough data on contamination of soil by polymers in general and particularly during ruination of road surface; perhaps because of lack of awareness and standard methods of quantitative evaluation of plastic components in soil. Current data suggest that flows of plastic have already reached the levels similar to other contaminants, for example, heavy metals. Migration is especially noticeable for plastic microplastics, but their impact on groundwater is currently almost unstudied. Therefore, there is an urgent need of additional studies in order to determine the fate and effects of those solid materials in terrestrial environment. The authors plan to study those issues in further researches.

Absence of legal basis and technical standards for work with polymers for road surface brings the problem of plastic roads to the legislative level.

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