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# Using of Production Wastes in Stormwater Drainage Purification

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**Abstract:** The climate change prognosis in the Kharkiv region shows an increasing danger of forest fires and negative consequences for the environmental components. In this article the negative impact from forests fires on the environment have been analyzed. The new method is proposed for cleaning the surface runoff, which is formed after a forest fire, by filtering in artificial or natural through the biological trenches using basalt chips of 0,5–2 mm in size as a filtration nozzle. Use of the proposed method of surface runoff purification will improve the water ecosystem sanitation and the increase of the ecological safety due to the production company wastes utilization. The proposed method of stormwater treatment is easy to operate, ecologically friendly and economically advantageous.

## 1 Introduction

The climate change has exacerbated the problem of fires and minimizing their consequences in most countries of the world. The increase of forest fire scales in Europe still is a huge problem, because of the forest's vulnerability from the global warming and low precipitation. A long term negative impact on wildlife with drought caused by fires is expected to increase [2]. In Ukraine, the annual average quantity of forest fires is about 3500, and the damage from them more than 5000 ha of green forest. The more vulnerable zones are located in the north and eastern Ukraine, where the annual percentage of forest fires is 37 and 40 respectively.

Many scientific works have been published about the prevention of emergencies, including forest fires and extinguishing methods [4-8]. But it should be noted that, in recent years, in the context of climate change, the number of forest fires has increased. In this connection, the development of measures for minimizing negative impacts from environmental emergencies is still an important issue.

The causes of fires are the high temperature conditions over a long period of time without any kind of precipitation in the southern and eastern regions, and the violation of public fire safety. Climate change studies in the Kharkiv region are devoted to this work [9,10]. The forecast of temperature change in the Kharkiv region, based on the annual monitoring from 1969 to 2017 year, predicts the increase of temperature by 1.7 °C by 2025. The forecast of climate change in the Kharkiv region shows that the risk of forest fires is continually increasing with the rising temperature and reduced precipitation.

The forest fires are not only a public concern but also have leverage on the regional and global ecological dynamics; which is, for example, emission of green gases and aerosols from fires to the atmosphere, soil contaminations, ground and surface water pollution, and destroying of some sensitive wildlife species. With the situation of decreased precipitation and rising temperature, the risk of fires and ecosystem loses in large areas is still high.

The goal of this study is to analyze the influence from forest fires on the environment with climate change conditions and also to show how to develop of environment measures for the negative impacts minimization.

## 2 Unresolved Issues

The increase of anthropogenic influences is boosting the forest fires rates. The main reasons of forest fires are: intense character of the public access to forest lands, close settlement allocation and recreational facilities, local traffic and climate conditions. The spreading of fires depends on condition and structure of plants and wind speed. Most fires happen in forests near big metropolises [11].

Among land fires, the most dangerous are forest fires, which are responsible for destroying wildlife, eroding soil and altering the river balance. The forest fires are the most serious phenomenon in the environment which leads to significant economical and ecological consequences [12].

The forest fires are the reason for the decrease of water regulation function, soil repair, sanitation, climate and environmental functions of the forest in natural ecosystems. The coastal forest destruction leads to the stagnation of river banks and siltening.

The quality of the surface water affects the discharges of production wastewater from industrial facilities and municipalities, diffuse sources, economical use of the landscape, climate changes, and geographical features of the river basins. The factors, based on the correlation connections that have the biggest influence on the ecological balance of the Oskol river in the Kharkiv region, were established. It shows that the diffuse pollution sources of the surface water are the main factor in the deterioration of aquatic ecosystems [9]. This study does not have propositions for reduction of the diffuse sources.

The goal of this study is to present a plan to improve of the methods of surface runoff treatment with use of production waste as a filtration nozzle and to decrease the influence from diffused sources in the water balance after forest fires.

To reach this goal some point targets were formed:

– to analyze the forest fires influence on the environmental condition;

– to improve the method of filtration of surface water with the use of the production waste (basalt chips).

## 3 Main Part

### 3.1 The analysis of influence from forest fires on the environmental condition

The ecological effects after forest fires are based on the air pollution with carbon dioxide and pirolises products from flammable timber materials and oxygen burning. The carbon dioxide is the major percentage in the anthropogenic pollution mass concentration. The ecological importance of the carbon burning processes and organic decomposition depends on a fire scale and the time that is needed for the vegetation recovering [13].

The carbon black, which is basically free carbon and the products of incomplete timber burning, include different organic components with lots of phenolic compounds, which have mutagenic and cancerogenic qualities, are thrown out in the air from the forest fires.

Smoky air leads to the deterioration of the surface microclimate, increases foggy days, and reduces the atmospheric transmittance, because of this visibility, brightness and ultraviolet radiation.

Forest fires have an influence on the radiation balance reduction, the increase of the heat are also affected to the soil, the turbulence heat stream change and convection strengthening. Due to the large surface of damaged forests, there are more than 104 Ha. The consequence of this could be local climate change [15].

Heat and smoke emissions from large forest fires change the atmosphere dynamic, the process of air recirculation, and weather conditions in some regions. The landscape features in some areas, which are placed in valleys and inter-mountain hollows, are formed from the stagnation of air masses, clear wind direction, and long periods of calm weather, that cause intense and long periods of smokiness from forest fires, which creates serious threats for the public health [16].

Huge amounts of contamination elements discharge to the water bodies with surface runoff from the woodlands after fires [3].

Forest plantations cause an impact on the quality of the surface runoff by absorbing, from the solution, cations and anions, improving the bacterial properties of water, and treating it from the suspended solids. These factors have an influence on the temperature balance of water objects. The forest creates the transition between surface runoff to the ground, and moreover decreases critical loads of surface runoff [17].

Forest fires have the responsibility for soil contamination through chemical substances including heavy metals, which lead to the ecosystem degradation.

Soil contamination by heavy metals is a threat to the plants, animals, surface and ground waters and human health [18,19].

Microorganisms have one of the most crucial roles of the sustainable level of soil productivity by the organic matter decomposition and recycling nutrients. But, their quantity could be reduced by stress factors such as extreme temperatures, pH, mineralization, chemical pollution [20].

The viability of microorganisms is decreasing with the increment of heavy metal contamination. Studies [21] showed that the heavy metal contamination in the soil has seriously affected the microorganism's community structures. In accordance with the study conclusion, the negative correlation has been noticed with the soil microbe biomass and heavy metal concentration.

Study [22] show that the presence of heavy metals is usually the reason of the decrease soil breathing and the negative correlation between the soil microbe breathing and heavy metal concentration is observed.

This paper is dedicated to the determination of the threat from the forest fires due to the presence of the heavy metals in the soil [23].

The studies of soil pollution by heavy metals due to forest fire in the pine forest in the Chuhuev district of the Kharkiv region (the village of Malunivka) showed that the multiplicity of excess gross of heavy metals by copper is 3.41 times, by zinc – 2.87 times, by manganise – 2.24 times (fig.1).

After the concentration of heavy metals increased, due to the forest fire, they were then flushed by the storm and melt waters to the water objects. In this connection, the development of the measures for the water ecosystem protection from the surface wastewaters after a forest fire is reasonable.

### 3.2. Improving the method of filtrating surface runoff using industrial waste (basalt chips)

The analysis of global data shows that the problem of stormwater and meltwater purification, especially on the territories without any kind of sewer system presence, is more than crucial.

The modern practice in the USA or some European countries, with the problem of the management and treatment of the stormwater runoff, forms the new approaches and solutions for this issue. In Germany, for instance, the new principle [24] for localization and treatment of surface runoff has been created, where the use of soil filtration processes plays a key role.

In the majority of European countries the problem of surface runoff treatment is solved by bioswales (mulds). These kinds of facilities have a negligible impact on the environment and are economically feasible. They are small, compact artificial linear channels with different forms and sizes, and they resemble landscape design elements.

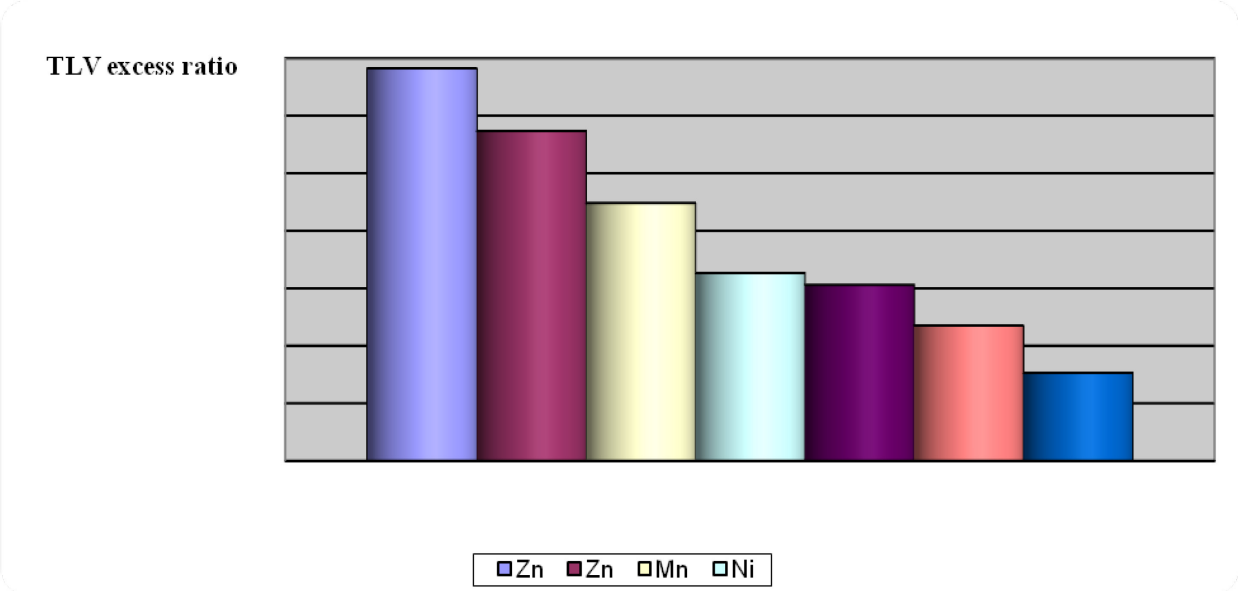


Fig. 1. The ranking of the polluted components by the multiplicity exceeding of the gross content of the metals in the soil as a result of the forest fire in the pine forest in the Chuhuiv district of thew Kharkiv region (the village of Malunivka)

One study [25] proposed a compatible treatment method of surface runoff from the agricultural land and municipalities or industrial wastewater on the mulds with filtration nozzles and bioreactor of full displacement.

It is proposed to improve the treatment of storm and meltwater, with the use of soil filtration capabilities and the effect of the treatment from polluted components increase due to the filtration layer of basalt chips, where the biofilm formations are formed and organic components absorb and purify wastewater filtrates to the lower sand layer.

This experimental device could be divided at two zones – aerobic and anaerobic. The first one includes the vegetation cover, the upper soil layer, and the filtration layer - where the main treatment process happens. The sizes of every zone are formed from the catchment area parameters and volumes of the rain that will enter the facility. The anaerobic zones consist of the sand layer. The anaerobic receives the treated wastewater, which purified on the filtration layer, and works as an additional filter, after which the purified wastewater filtrates to the lower soil layer [25].

In the aerobic zone processes of treatment suspended solids on the vegetation cover, the adsorption of contaminants on filtration nozzles and aerobic biodegradation happens. If the upper layer has an intense filtration qualities (5 sm/hour and more), the aerobic qualities could be saved [25].

The filtration layer is the upper layer of black soil – with a thickness of 6 cm, filtration nozzle layer – with a thickness of 35 cm, and the layer of sand – with a thickness of 14 cm. A schematic diagram is shown in fig. 2.

It is proposed to use basalt chips, in the vegetative channels as the natural filtration layer, which is a waste product to use from the basalt production plant.

Basalt chips with a size of 0.5-2 mm have been chosen as the filtration layer due to the resistance to weathering (resistance to temperature variation and hardness), and possibility of regeneration without losing general characteristics (for example, water steam washing).

Physical and chemical characteristics of basalt chips presented in the table 1.

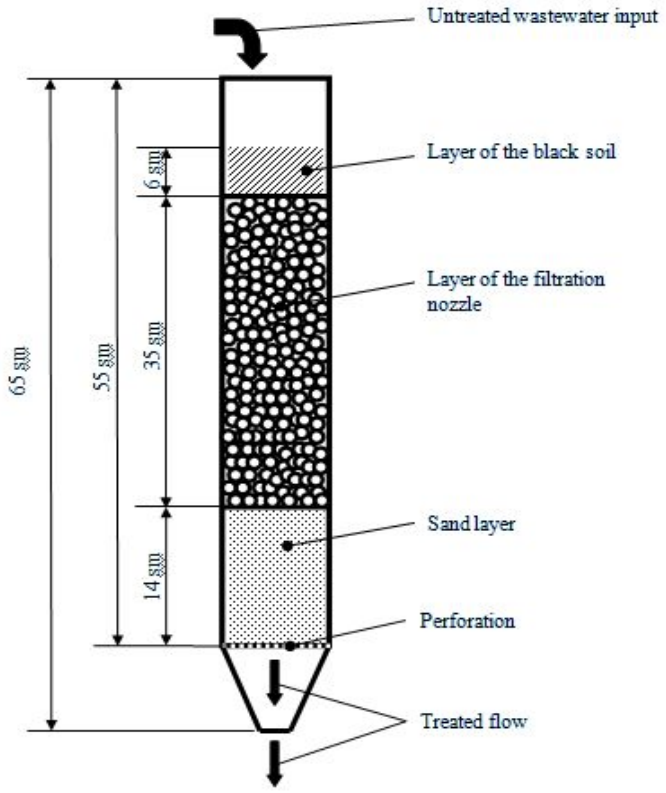


Fig. 2. Schematic diagram of surface runoff filtration [25]

Table 1. Physical and chemical characteristics of basalt chips

| Indicator | Unit | Value |
|---|---|---|
| Fraction | | |
| On the sieve (мм) | | |
| > 1,6 | % | 0,0 |
| 1,4 | % | 2,57 |
| 1,25 | % | 23,12 |
| 0,8 | % | 16,94 |
| 0,63 | % | 47,89 |
| 0,5 | % | 5,53 |
| 0,1 | % | 3,69 |
| < 0,1 | % | 0,26 |
| Chemical composition | | |
| $SiO_2$ | % | 49,06 |
| $Al_2O_3$ | % | 15,70 |
| FeO | % | 6,37 |
| $Fe_2O_3$ | % | 5,38 |
| Other substances | % | 23,49 |
| Physical properties | | |
| Moisture | % | < 2 |
| Specific weight | $g/sm^3$ | 2,7-2,9 |
| Bulk density | $g/sm^3$ | 1,32 |

For the experiment, the basalt chips were delivered from the stockpile of the production company “Basalt Ukraine’ (in the village of Zlazne, in the Kostopil district, Rivne region, Ukraine).

The modelling of the infiltration process took place in the square column form of plexiglass (Polymethyl methacrylate) with the side lenth – of 15 cm and height of – 65 cm.

The stormwater runoff splashed through the small injector, the pressure was regulated by a manual valve. The sampling procedure was carried out after the all volume through the device. The pollution indicators were established: suspended solids, oils, COD, and mineralization. These pollutants are typical for the surface runoff from urbanized and non-urbanized territories of different regions. Analysis was carried out in accordance with standard, certified methods.

The experiments showed the high treatment efficiency of stormwater runoff by suspended solids – 98%, COD – 68.6%, oils – 92%.

It should be noted that the surface runoff after forest fires contain a lot of organic and specific components. Therefore, for a better treatment process, methods of the phytoremediation have been proposed.

Natural methods with the use of aquatic plants for the intensification of the treatment processes are used for the different types of wastewater and surface runoff in the many countries of the world.

The economical benefits of such methods consists of many factors; for instance, easy to use construction system with vegetation, absence of complex mechanisms for the water level or volume regulation, absence of any kind chemical reagents, and the fact that it could be operate without professional staff, etc.

For the interception of the most polluted part of the runoff a combination of several facilities are used, each of them has their own purpose and increase the overall treatment process. This system includes the bioswales, filters and soil dams. The aim is to intercept the most polluted flow after 15-20 minutes of rain.

Such constructions are placed near reservoirs in the path of the pollution runoff, which intercepts and purifies due to the natural biochemical processes in the dams and trenches or through the underground water flow, where natural processes of soil treatment also happens.

## 4 Conclusion

The forest fires adversely affect all components of the natural ecosystem, especially on air pollution, surface water balance, soil, loss of wild life species and microclimate change. The forecast of the climate change in Kharkiv region indicates the danger in the increase in the incidence and area of forest fires. There fore developing measures to protect the natural ecosystem from the negative impact of forest fires is a very urgent task.

The analysis of the modern management waste regulation system in Ukraine showed it is incompetent. Utilization and disposal of the industrial and municipal wastes are the priorities of environment protection, public health and rational use of the natural resources, therefore the proposal for the basalt chips to be used as a filtration layer for the surface runoff treatment is quite relevant.

Basalt chips are some of the stockpile waste from the Ukrainian production companies, in such cases using it as a filtration nozzle allows us to enhance of the utilization of the production waste and decrease the impact on the environment.

The device for the runoff treatment does not require any kind of pumps or pipelines for sewer discharge, and therefore is more economical and energy-saving. It could be used, not only in the urbanized areas and industrial sites, but also in agricultural land and on woodland belts. The proposed method could be use in areas with a low level of the ground water allows recharging and increasing volumes of the underground waters due to the more effective infiltration system and localization of stormwater during rainfall.

Experiments showed the high efficiency of the use of basalt chips for the stormwater treatment in the bioswales. In order to more effectively treat wastewater after forest fires the phytoremediation methods are proposed. The actual proposal for the plants – phytoremediants, depends on the geographical and physical conditions, landscape features and soil type. The method of the treatment of the surface runoff provides an economical and easy to use solution for the problem of pollution

from diffuse sources reduction of the ecological balance of the surface waters and also the minimization of the amount of the production wastes accumulation.

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