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IMPACT OF RAINFALL ON THE MICROPLASTICS BEHAVIOR IN THE ENVIRONMENT

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Abstract: In recent decades, environmental pollution from microplastic (MPs), plastic particles smaller than 5 mm, and climate change have received international attention. However, these two issues have been primarily investigated separately hitherto, although they exhibit a cause-and-effect relationship. In water environments, previous researches have mainly been focused on investigating the impact of human-related activities on microplastic degradation, but little is known about non-anthropogenic effects on microplastic distribution. In this paper, the main focus was to investigate impact of rainfall on microplastic behavior in the environment. The preliminary results of this study imply a close relationship between rainfall and plastic behavior in the environment and the adsorption possibilities of metal adsorption on plastics and microplastics. It also opens up some questions regarding possible leaching of metals from plastic surface into the environment highlighting the importance of this research.

Keywords: plastic, microplastic, rainfall, metals, sorption

1. INTRODUCTION

In the past few years, plastics have been widely utilized in industries, agriculture, medical treatment, and products that closely relate to human daily life. Due to its exceptional properties, such as low cost, high resistance to corrosion, light weight, durability, and outstanding insulating properties, today its usage is inconceivable. Despite the convenience plastic products bring, a growing amount of plastic waste is inevitable [1,2]. The advantages of plastics, which are mentioned earlier, can lead to serious environmental problems due to their persistence, accumulation, and strong resistance to degradation when they are transformed into plastic waste [3].

Microplastics (MPs), which are commonly referred to as plastic particles <5 mm in size, have received a significant amount of attention in scientific world [4–9]. Due to their specific physical properties, microplastics can have negative effects on organisms. Furthermore, MPs that are ingested can result in a loss of energy, growth inhibition, oxidative stress and even death of some organisms. On the other hand, various toxic leachable additives are frequently added in the process of plastic production to modify the material properties of polymers. Moreover, MPs have the potential to adsorb organic pollutants and metals, which can increase the potential exposure risks of these pollutants [8,10–13].

Research on MPs pollution in freshwaters and soil is scarce compared to marine ecosystems. Furthermore, numerous studies on freshwater and soil have given priority to evaluating the level of MPs pollution, the level of MPs distribution and its source. There is a lack of knowledge about the impact of non-anthropogenic factors, such as rainfall, on MPs pollution. Rainfall has been proven to be one of a significant factors for other pollutants and materials in previous studies. As it's been implied by other authors, the transfer of components adsorbed on MPs and MPs itself from landfills to different water bodies may be influenced by rain or runoff [2]. Therefore, rainfall can be the most direct way for organic and inorganic pollutants runoff from MPs surface. In order to fill these knowledge gaps, in this study, for the first time in Serbia, the authors did preliminary research regarding impact of rainfall on the microplastics behavior originated from plastic net typically used as in gardens and fields.

2. MATERIAL AND METHODS

In order to investigate potential influence of large amount of rainfall on MPs behavior in the environment the experiments were conducted in laboratory-controlled conditions. For the experiment, in this study were used plastic net (five pieces of plastic net sizes 10x10 cm) commercially available for gardens and fields. Additionally, water used for simulating large amount of rainfall, when it was missing, was a tap water.

The characteristics of the water mixture collected during the experiment are presented in Table 1.

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Table 1. Characteristics of the water used during the experiment

Parameter	Method designation	Method description	MDL	PQL	Water before contact with plastic
pH	SRPS H.Z1.111:1987	Electrochemical	-	-	9.55
Electro conductivity 25 °C (mS/cm)	SRPS EN27888:1993	Conductometry	0.51	2.57	1.26
Turbidity (NTU)	APHA 2130 B	Nephelometry	-	-	14.44
Total organic carbon (mgC/L)	SRPSISO8245:2007	Combustion and IR	0.20	0.46	36.6

In order to simulate rainfall, an ordinary glass bottle with a perforated cap was used. When there was are no rainfall, watered was performed 3-5 times a day. With the increasing of water volume in collecting can with plastic net, the watering was reduced to twice a day, in the morning and in the afternoon. The rainfall simulation was performed slowly, and the amount of water used was 100 ml. Once a month, the water is removed from the can and analyzed. In this paper, results for the first, preliminary, month are presented.

During the experiment monitoring of selected parameters (the amount of rainfall, temperature, air humidity, air pressure and the amount of water used for irrigation) were conducted. Additionally, pH value, electrical conductivity (EC), concentration of total organic carbon (TOC) and total content of selected metals were measured in water samples before and after watering the MPs. The pH value of the water samples was measured using a pH-meter 340i, WTW, SenTix®21 electrodes, according to the SRPS H.Zi.111:1987 method. Additionally, the analysis of electrical conductivity of water samples were performed using a Hanna model HI 933000 conductometer. TOC in water samples were analyzed using the Elementar LiquiTOCII apparatus according to the SRPS ISO 8245:2007 method.

The total content of selected metals (B, Al, Cr, Mn, Co, Ni, Cu, As, Cd, Sn, Ba and Pb) in the mixture rainfall water and tap water before and after watering plastic net was determined by using Inductively coupled plasma mass spectrometry with mass detector (ICP-MS) (Agilent Technologies 7700 Series ICP-MS). Method detection limits for the selected metals were 0.001 mg/L.

3. RESULTS AND DISCUSSION: GENERAL EXPERIMENT PARAMETERS MONITORING

The mixture of tap water and rainfall collected in separated can has a high concentration of total organic carbon 36.6 mgC/L, turbidity 14.4 NTU and electro conductivity 1.26 mS/cm which is presented in table 1. Additionally, monitoring of the amount of rainfall, temperature, air humidity, air pressure and the amount of water used for irrigation is shown in Fig. 1. The results presented in Figure 1. imply that the amount of rain in this experimental period fluctuated and ranged from 0 to 12.6 mm/m^2.

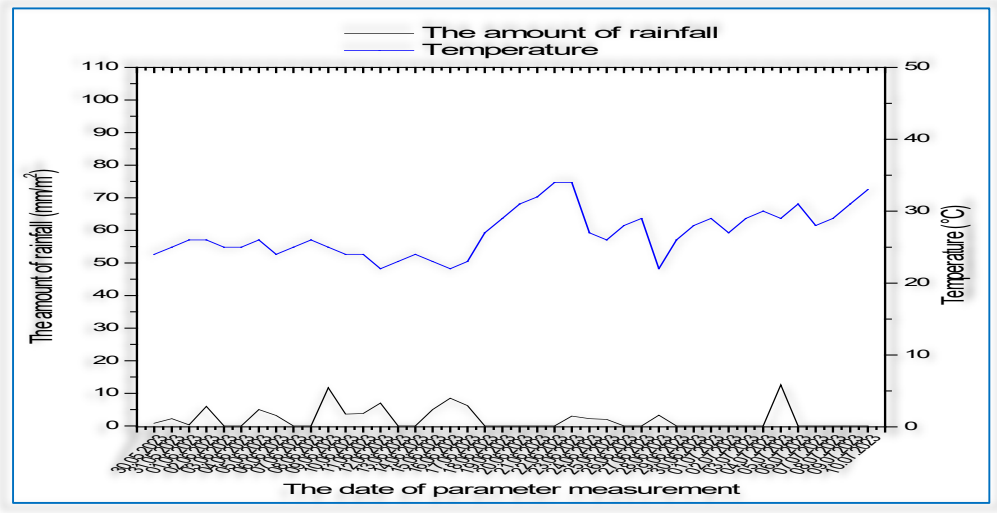

Figure 1. Monitoring of the amount of rainfall, temperature, air humidity, air pressure and the amount of water during the one-month period Figure caption

Furthermore, based on the Figure 1 the rainfall simulation with 100 ml of tap water fallowed the data with no rainfall. Additionally, temperature measured during this one-month period and shown in Figure 1 imply high temperature fluctuations ranging from 22˚C to 34˚C and possible impact on plastic behavior in the environment. Furthermore, in order to investigate impact of simulated rainfall on plastic behavior, pH, TOC, EC and turbidity was measured also in water after watering the plastic net which is shown in Figure 2.

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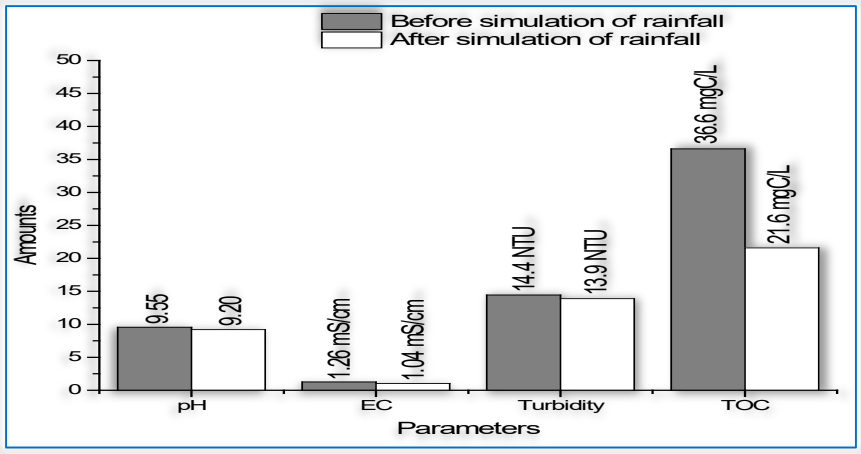

Figure 2. pH value, electrical conductivity (EC), turbidity and concentration of total organic carbon (TOC) before and after simulation of rainfall influence of plastic net behaviour

The results shown in Figure 2 imply that values for all analyzed parameters decr rainfease after contact with plastic net. Therefore, pH value decreases from 9.55 to 9.2, EC from 1.26 to 1.04 mS/cm and turbidity from 14.4 NTU to 13.9 NTU. The highest decrease was detected in TOC values where the amount variated from 36.6 mgC/L before contact with plastic net to 21.6 mgC/L. Based on the results presented in Figure 2. it can be assumed that certain amount of organic carbon has been adsorbed on the plastic net [13–15].

In order to get more information about simulation of rainfall on plastic net concentration of selected metals before and after watering were conducted by using ICP-MS and the results are presented in Figure 3.

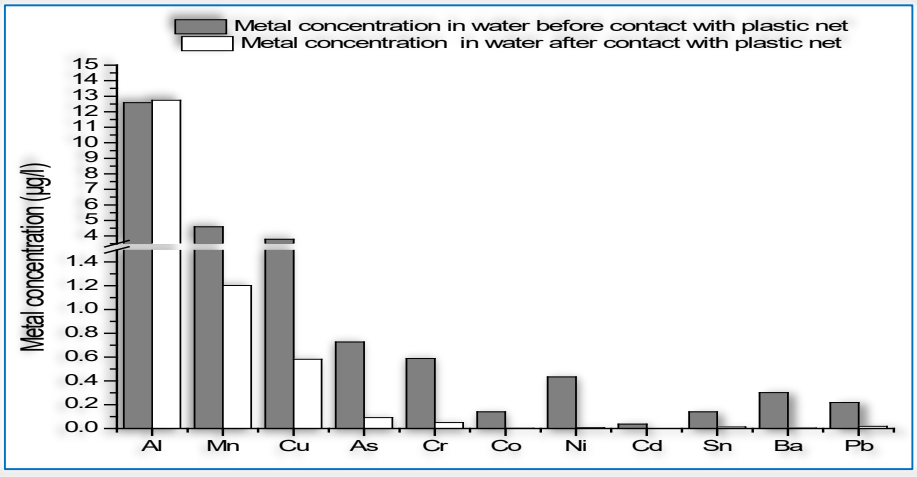

Figure 3. Concentration of Al, Mn, Cu, As, Cr, Co, Ni, Cd, Sn, Ba and Pb In water before and after contact with the plastic net

Generally, results presented in Fig 3. imply that concentrations for all selected metals (except Al) decreased after simulation of rainfall and its contact with plastic net. Furthermore, based on the results presented in Fig. 3, it can be assumed that the adsorption of selected metals also occurred on plastic net. Based on the obtained results, the highest adsorption percentage was detected for Cd, 99.1%, and the lowest for Mn, 73,8%.

In sum, the topic of emerging concern is the impact of rainfall on MPs' behavior in the environment and the potential adsorption of heavy metals. MPs that are ubiquitous can be transported from the soil to underground waters, through the food chain, and different organisms to humans, resulting in a serious threat to human health. It is unfortunate that the actual risks of exposure to MPs and metals in human health are not fully known [13,16].

4. CONCLUSION

This preliminary study demonstrated a close relationship between rainfall and plastic behavior in the environment. Obtained results, and adsorption possibilities of adsorption of organic matter and metals

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implies high importance of investigation of non-anthropogenic factors, especially rainfall. It is important to continue research in this field with high frequency sampling in order to get accurate conclusions and calculations regarding adsorption affinity of TOC and metals on plastics and microplastics. It also opens up other questions regarding possible leaching of metals from plastic surface into the environment which is something that this working group is planning to investigate in future period.

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