THE BLACK SEA AND MICROPLASTICS: SEVASTOPOL BEACHES MONITORING

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Within the framework of the monthly monitoring the study of qualitative and quantitative composition and distribution of micro- and small macroplastic on sandy and pebbly beaches of Sevastopol is initiated. Microplastics and small macroplastic abundance was estimated from surveys on two of the most popular Sevastopol sandy beaches of the Crimea Black Sea Coast (Omega beach and Uchkuyevka beach). The samples were collected during March - April 2016 from the top 5 cm of the numerous square areas (1×1 m) placed on 20 m long transects perpendicularly 100-meter lines along the shore line. Three type of stainless steel sieves were used: mesh sizes 5 mm, 1 mm and 0,3 mm. In the laboratory, the collected sediments were introduced into a glass tank with a high concentration solution of sodium chloride (NaCl) 140 g l^{-1}, the floating plastic particles recovered, sorted and categorized by type, usage and erosion level.

The mean microplastics densities on Omega and Uchkuyevka Beach were 4,2 ± 0,95 and 2,6 ± 0,95 items m^{-2}, accordingly. Most of micropastics items were rigid fragments (60%), polystyrene (25%) and polyethylene (15%). Number of macroplastic particles (size of 5-100 mm) by 1 m^{-2} ranged from 2.35 to 57, the mean abundance on Omega and Uchkuyevka beaches were 10,1 ± 0,95 and 7,3 ± 0,95, accordingly.

Key words: the Black Sea, marine debris, microplastics, marine litter monitoring

I. Introduction

Plastic rapidly gained popularity (the mass manufacturing of plastic products began with 50s of the 20th century) and has become an irreplaceable material in the modern world of industry. And also rapidly plastic turned into one of the most unpredictable and dangerous elements of environmental pollution. Due to light weight plastic products sooner or later fall into the water, making suffer primarily coastal ecosystems. Particularly vulnerable to the accumulation of plastic waste are places of recreation, where the influx of tourists is constantly exacerbating the problem.

The complexity of the process of decomposition of various plastic materials is still the subject of research discussions. According to the majority of the researches plastic degradation process duration ranges from 100 to 1,000 years, but even before disintegrating monomers plastic in nature is not fully utilized [15] due to it high resistance to microbial decomposition [12].

Aging of plastic material occurs by heat, ultraviolet light, atmospheric oxygen, water, ozone, radiation, and accompanied by cleavage of polymer chains, which causes a change in the starting polymer properties: loses elasticity, fragility and increased rigidity, the surface becomes rough. The plastic breaks down into tiny particles, becoming a so-called "microplastics" - particles with a diameter less than 5 mm [1, 3, 11, 13].

A large proportion of plastic waste are in the waters of the World Ocean (80%) falls on microplastics [18]. With dimensions comparable to the size of zooplankton and less [2] microplastics particles can be absorbed by hydrobionts, thus including in the food chain processes, which the end part may be human.

And if the first reports of researchers who discovered microplastics back in the 70s of the 20th century (in the North Sea [5] and in the Atlantic Ocean [10]) did not arouse interest in the scientific community is today published more than 50 works devoted to the study of plastic debris on beaches and more 150 - in general, of research microplastics in aquatic ecosystems, sampling methods, qualitative and quantitative analysis, the role of it in the food chain, the impact on human health, etc. This concern shows an awareness of the possible catastrophic consequences for the marine and terrestrial ecosystems that may cause microplastics.

After all, in addition to purely mechanical blockage of the gastrointestinal tract of aquatic organisms, their hemolymph and other organ systems [6, 7, 8, 9, 14, 18], resulting in the disruption of physiological processes, tissue ruptures and organs and so on, microplastics, while in the sea water is able to accumulate toxic organic impurities (organohrornye pesticides bisphenol A, and others) at concentrations of less than from $ng \cdot g^{-1}$ to $mg \cdot g^{-1\ -1}$. Once in the body, these highly stable compounds tend to accumulate in fatty tissues and are often carcinogenic, teratogenic and mutagenic effects.

Accumulation of plastic inside of lysosomes coincides with breakdown of the lysosomal membrane and release of degrading enzymes into the cytoplasm causing cell death [21]. Furthermore, the experiment [4] showed that sorption of nano-sized plastic beads to algae (one freshwater and one marine species) hindered algal photosynthesis and appeared to induce oxidative stress.

To understand the mechanisms of plastic waste effect on marine ecosystems is necessary to conduct a large-scale and long-term monitoring of the marine environment, including seabed [3, 16]. Similar studies by Russian scientists at the Black Sea region, unfortunately, has not yet been carried out. Therefore, the aim of our work is to evaluate the impact of microplastics on the ecosystem of the Black Sea and the establishment of the main ways the evolution of plastics generation in recreational areas.

II. MATERIAL AND METHODS

Study area

To accomplish this goal we have initiated monitoring of qualitative and quantitative composition of micro- and small macroplastics (5 – 100 mm-sized) in areas of sandy-pebble beaches of Sevastopol, the surface layer of water (5 - 10 cm), water column (5, 15, 30 m), bottom sediments.

Initially, we have chosen two of the most popular sandy beaches in Sevastopol: Omega beach and Uchkuevka beach (Fig. 1).

Uchkuevka beach is located on the North side of Sevastopol (44°38'43"N 33°32'9"E). Type of the beach – sandy-pebble. The length of over 1,5 km. Sea depth within 6-7 meters from the shore up to 2 m. The beach has an excellent infrastructure: rides, restrooms, first-aid station, rescue station, a variety of bars, cafés, various shops selling beach and associated equipment.

Omega Beach is located on the western shore of the Omega (round) bay (44 ° 35'51 "N 33 ° 26'35" E). The bay is very shallow. The beach is popular with guests. In the area there is a huge number of bars and cafes. Water sports - boats, bicycles, "banana", jet ski, etc. There is a small beach on the opposite side. Type - sandy. The length - 700 m.

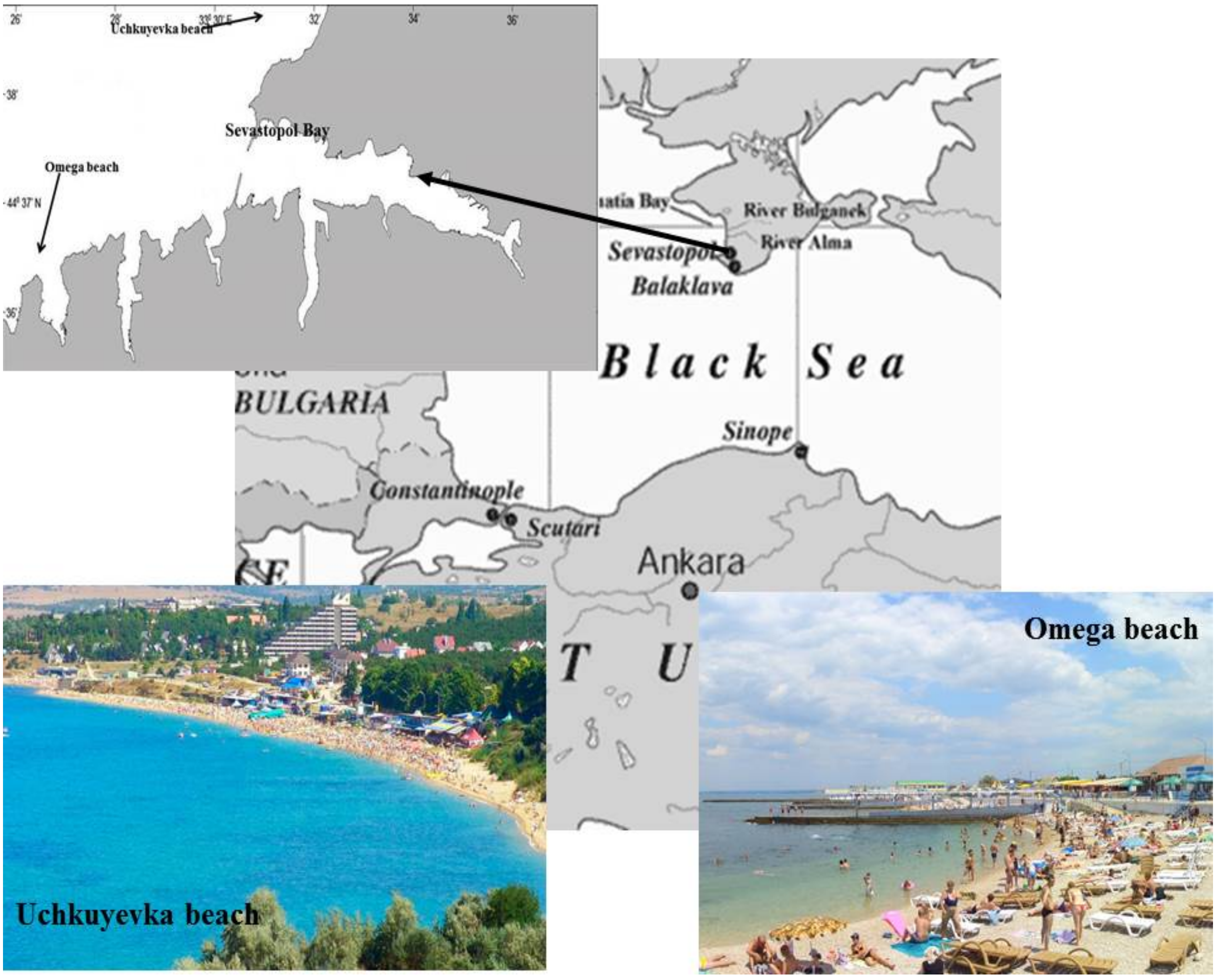

Fig. 1. Study area

Sampling method and analysis

The samples were collected during March - May 2016. Since the length of both the beaches is more than 500 m, we have chosen the central part and lay on both sides of the 100-meter intervals. Firstly we lay out one 100-meter tape measure along the shore line to select the area of beach to be analyzed. Then we select four transects between 0 and 100 m perpendicularly to the tape measure and run from the back beach (vegetation side) to the sea wall.

Then we placed three stations (quadrants 1×1 m) along transect, in the wrack line, mid beach and back beach. Recorded GPS for each quadrant. Therefore, every month on the each beaches we have collected samples from 50 stations (Fig. 2). Removed big pieces of natural debris (seaweed, leaves, wood). With a scoop we removed sediment from the top 5 cm and put in 5-galon bucket. When the bucket is half full of the sediment we added water and stired the sand with a stick to make everything float to the top. Then we poured the water through the nested sieves.

Three type of stainless steel sieves were used: mesh sizes 5 mm, 1 mm and 0,3 mm. The biggest sieve was on top in order to it catch the seaweed and larder plastics, while the smaller sieves on the bottom will catch smaller items.

Fig. 2. Sample collection on one of the stations (quadrants 1×1 m)

We have repeated this three times per each quadrant (fill with water, stir, sieve). Picked through the bottom two sieves for any plastics with squirt bottle and put it into sample 0,5 l volume container (glass tank with metal top). The sample tanks were labeled and brought into the lab. In the laboratory, the collected sediments were introduced into a glass tank with a high concentration solution of sodium chloride (NaCl) 140 g l^{-1}, the floating plastic particles recovered, sorted and categorized by type.

Density of micro- and macroplastics items (number of items m^{-1}) was calculated for each quadrant. The items were categories according to the:

1. Type of polymer material (polyethylene, polypropylene, cellulose acetate etc.),
2. Type of items (plastic fragments, pellets, filaments, granules, plastic films);
3. Shape of items (for pellets: cylindrical, disks, float, ovoid, spheruloids;
   for fragments: rounded, subrounded, subangular, ungular;
   general: irregular, elongated, degraded, rough, broken enges);
4. Erosion level: fresh, unweathered, incipient alteration, and level of crazing (conchoidal fractures), weathered, grooves, irregular surface, jagged fragments, linear fractures, subparallel ringes, very degraded).

III. RESULTS AND DISCUSSION

Microplastics particle number in the spring (March-May 2016) on the beaches varies from 0.670 to 7,597 items m^{-2}. The mean microplastics densities on Omega and Uchkuyevka beaches were 4,2 ± 0,95 and 2,6 ± 0,95 items m^{-2}, accordingly [17] (Tab. 1). The maximum measures of micropastic items average densities was on Omega beach, the mean were in 1,6 time more the same on Uchkuyevka beach. Most of microplastics items were rigid fragments (60%), polystyrene (25%) and polyethylene (15%).

Table 1. Microplastic abundance on Sevastopol beaches in spring 2016

Month/ Beach name	Omega beach		Uchkuyevka beach	
	Average densities (items m^{-1})	Maximum densities (items m^{-1})	Average densities (items m^{-1})	Maximum densities (items m^{-1})
March	4,1	6,8	2,8	3,4
April	3,6	5,2	2,9	3,6
May	4,9	7,6	2,1	3,0
Mean densities (Spring)	4,2	6,5	2,6	3,3

Also we estimated small macroplastic particles abundance (5 – 100 mm-sized) from the same investigated square areas. Macroplastic particles mean abundance were 10,1± 0,95 and 7,3 ± 0,95 items m^{-2} on Omega and Uchkuyevka beaches, accordingly (Tab. 2).

Table 2. Macroplastic abundance on Sevastopol beaches in spring 2016 (5 – 100 mm)

Month/ Beach name	Omega beach		Uchkuyevka beach	
	Average densities (items m^{-1})	Maximum densities (items m^{-1})	Average densities (items m^{-1})	Maximum densities (items m^{-1})
March	8,2	57	6,5	24
April	9,1	44	5,8	28
May	13	30	9,6	18
Mean	10,1	43,7	7,3	23,3

It should be noted that our samples included both plastic particles type: fresh and accumulated over probably long enough period of time, as indicated by the high degree of roughness and the particle edges cracks formation. High-level-degradable plastic particles formed the majority of the beach litter on the both beaches.

Our data are comparable with the data of our colleague, whose work on the study of distribution and sources of marine debris (including small macroplastic) on the Black Sea beaches of the west coast of Turkey is of the first such works in the Black Sea region. According to him the number of the plastic particle size of 2-10 cm to 1 m^{-2} ranged from 0,085 to 5,058 units. Most of them are bits of hard plastic items, such as caps for PET bottles.

Table 3. Classes of plastic material that are commonly encountered in the samples

Plastic class		Products and typical origin	Percentage abundance	
			Omega beach	Uchkuyevka beach
Polyethylene	LDPE, HDPE	Plastic bags, bottles, drinking straws, netting; Milk and juice jugs	6,25 %	13,4 %
Polypropylene	PP	Rope, bottle caps, netting	14,2 %	16,5 %
Polystyrene	PS	Plastic utensils, food containers	40,0 %	30,2 %
Foamed Polystyrene	4,9	Floats, bait boxes, foam cups	4,2 %	3,0 %
Polyvinyl chloride	PVC	Plastic film, bottles, cups	8,4 %	17,4 %
Cellulose Acetate	CA	Cigarette filters	25 %	18 %
Unidentified		-	2,0 %	1,5 %

In accordance with our data macroplastic particles number varies from 2,35 to 57 items m^{-2} (Fig. 3).

Fig. 3. Omega beach sample from one of the stations (quadrant 1×1 m)

Such a huge number of small macroplastic particles on our beaches, is probably explained due to lack of a proper level of regular garbage cleanups and low culture vacationers themselves, as evidenced by at least a high amount of cigarette filters (Tab. 3).

Statistical analysis confirms that micro- and small macroplastics particles were significantly more abundant on Omega beach, than on Uchkuyevka beach. That is not surprised, cause the location: Omega bay is more closed, comparable with open Uchkuyevka beach shore line. Perhaps some of the plastic waste is constantly inflicts on the beach with the sea. Therefore, it will be important to find out the sea- and land-based sources of plastic litter in our further investigations. The monitoring will be continued on other Crimea Black Sea Coast beaches to quantify and qualify coastal litter pollution and develop effective mitigation measures.

IV. Acknowedgments

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