Study concerning the pollution of the marine habitats with the microplastic fibres

Article *in* Journal of environmental protection and ecology · November 2014

Impact Factor: 0.84

5 authors, including:

Timar Adrian

University of Oradea

14 PUBLICATIONS **0** CITATIONS

SEE PROFILE

Alin C. Teuşdea

University of Oradea

28 PUBLICATIONS **35** CITATIONS

SEE PROFILE

STUDY CONCERNING THE POLLUTION OF THE MARINE HABITATS WITH THE MICROPLASTIC FIBERS

POPA MARIA[1], MORAR DAN[1], TIMAR ADRIAN[2], TEUSDEA ALIN CRISTIAN[2], POPA DORIN[1]

[1] *"1 Decembrie 1918" University of Alba Iulia, 11-13 Nicolae Iorga Street, 510 009 Alba-Iulia, Romania,*

[2] *Oradea University, Universitatii Street, no. 1, Oradea, Romania*

Corresponding authors: mariapopa2010@yahoo.com, morar.danny@gmail.com

Abstract

Micro plastic fibres pollution of the marine habitats is an environmental issue that extends and aggravates at the same time with the development of the plastic industry which recorded an increase of 9% per year, getting from a production of 1.7 million tons in 1950 to 280 million tons in 2011. Through the degradation process, the plastic wastes can deliver chemical substances in the sea being thus a threatening for both flora and fauna. At the same time, plastic particles absorb the persistent organic pollutants (POP) from the sea and after their assimilation; they transfer the toxic substances in the bodies of the sea animals, causing serious troubles in their growth or reproduction processes. The statistical analysis was intended to interpret and correlate the micro plastic fibres pollution in the studied areas. In the performed tests using statistical methods such as ANOVA, revealed that zoning beaches generates statistical variability, and using the Post-HOC Tukey test and Principal Components Analysis, was performed the grouping of the analysed beaches on pollution levels and their comparison. The physical characteristics of the identified micro plastic fibres were also determined, and it was obtained the volume of the micro plastic fibres pollution from all the studied beaches. Afterwards, the quantity of pollution was correlated with the resulted volume, and the differences caused by the physical properties of the microfibers that were identified in the microscopic examination.

Keywords: Micro plastic fibres, marine habitat pollution.

.

AIM AND BACKGROUND

Plastics are everywhere in society and environment, especially in the marine environment where huge amounts of waste plastic accumulate. People's level of education and knowledge on the environmental dangers and risks posed by the presence of these wastes in the marine habitats, is very low. The serious problems that come to the attention of researchers in recent years are caused by these plastic micro particles that are a threat to the aquatic life[1]. Although this problem was not paid attention so far, large and growing

amounts of plastics products, wastes, fragments are in the oceans and seas, both on the surface and deep seabed, on the coastal lines, as well as in sediments and organisms[2].

Plastics constitute between 60-80% of the marine environment waste, and 90% of the waste floating on the seas and oceans[1]. Most times, when it comes to plastic waste, we think of waste remaining after consumption of certain products such as PET bottles, detergent containers and food packaging. This is only part of the picture that describes the complexity of this problem. Small pieces of plastic, also called micro plastics that most times we cannot see with the naked eye, are a greater threat to the environment[3-5].

Alarming amount of plastic waste was found in the marine environment around the world, both on the shores of seas and oceans and on the beaches[3-4]. According to statistics, micro plastics are abundant in the marine environment. For example, a study by Richard Thompson, a researcher who has studied the problem of micro plastics pollution in the North Sea, estimated the accumulation rates to approximately 100 million pounds per year[1]. Another study has reported the presence of micro plastics in 55 of 76 locations studied in the north Pacific, in quantities of 0 to 3.52×10^6 pieces/km^2, resulting in an average of 1.74×10^5 pieces/km^2. In the north Pacific currents area, the micro plastics average was 3.34×10^5 pieces/km^2.

EXPERIMENTAL

During investigations, sand samples from the Black Sea were analysed. The presence of micro plastic pollution was observed in the locations studied, while the level and dispersion of pollution varies depending on the beach location and on the beaches take-up during summer. Soil sampling in Romania – Constanta County, was conducted between the 8th and 11th of October 2012. Samples were taken from four resorts on the Black Sea: Costineşti, South Eforie, North Eforie and Mamaia.

Material and Methods

The microscopic fibres present in the sand samples were separated from the deposit by a saturated solution of sodium chloride. This solution allows the fibres to float on the surface and can thus be filtered. The saturated solution was prepared by mixing 220g of NaCl with 700 ml of distilled water to dissolve the entire amounts of NaCl. For weighing the amount of salt used, the analytical balance Acculab Atilon was used. After filtration of the supernatant, the filter paper is transferred to a Petri plate using a metal tweezers

to avoid contamination. All these steps are repeated three times in order to obtain three identical filtering for each type of sand sample. The filters obtained are analysed under a microscope, counting the plastic microfibers identified. The result of the three filtering on each site is the number of fibre per 50 grams of sediment. For the microscopic analysis the Zeiss Primo Star microscope was used, and to capture images, the Canon Powershot G9 (4x zoom). The volume of micro fibres was determined from the digital images captured under a microscope. Digitizing the microfibers involved marking the microfiber area with an artificial colour (i.e. blue). The area was extracted by using a colour filter for which the micro-fibre's average length and diameter were determined. In the first step, the numerical values of these quantitative parameters were calculated in pixels by the microfiber "skeleton method". In the second stage, by calibrating the microscope, the size of a pixel metrics was determined (1pixel = 0.5 microns). The metric values of the length and average diameter parameters were calculated, and finally the volume of each micro fibre. The cumulative volume is the sum of volumes of all the fibres in a beach area.

RESULTS AND DISCUSSIONS

The paper work intends to answer some of the environmental issue: which beaches sand and which beach zones are the most polluted ones from the Romanian Black Sea shore.

First step answering these questions is to assess the number and their limits of the ***micro plastics*** pollution levels. Authors propose to correlate the micro plastics pollution level of the beaches with the statistical quartiles and their limits (see table 1 and 4).

Table 1 The results of laboratory analyses of the samples from the Black Sea

No.	**Beach**	**Cardinal Point**	**Filtration results**			**∑ per area**	**Mean/ area**	**∑ per beach**	**Mean/ beach**
			1	**2**	**3**				
1	Costinești 1	North	24	36	20	80	26,66	205	68
		Centre	37	11	13	61	20,33		
		South	12	21	31	64	21,33		
2	Costinești 2	North	46	38	45	129	43	412	137
		Centre	21	32	33	86	28,66		
		South	83	47	67	197	65,66		
3	South Eforie	North	13	18	10	41	13,66	186	62
		Centre	15	21	24	60	20		
		South	26	25	34	85	28,33		

4	North Eforie	North	17	16	13	46	15,33	121	40
		Centre	10	8	11	29	9,66		
		South	12	16	18	46	15,33		
5	Mamaia	North	18	23	21	62	20,66	653	218
		Centre	17	16	17	50	16,66		
		South	260	145	136	541	180,33		

The table (1) emphasizes major plastic microfiber pollution in Mamaia, with an average of 218 micro fibres, followed by Costinesti 2, where the average is 137 micro fibres. The high level of pollution is caused by the large numbers of tourists, as Mamaia and Costineşti are among their preferences. With these four pollution levels were classified the beaches zones and beaches as severe, high level, average level and low level of pollution (see tables 2 and 5 – with the appropriate colours for each level: severe with black, high with dark grey, average with light grey and low with very light grey). In the table 2 we show the descriptive statistics for one-way ANOVA with the factor: beach zones (N-North, C-Centre, S-South), for all the beaches over the variables: number and volume of microfibers. (OPL means Ordinal Pollution Level).

Table 2. Descriptive statistics for one-way ANOVA with the factor: beach zones

	Volume	**Number**	**OPL**
No. of values used	45	45	
Minimum	**31666.776**	**8.000**	
1st quartile	**158322.669**	**15.500**	**1**
Median	**260230.424**	**21.000**	**2**
3rd quartile	**389581.652**	**34.000**	**3**
Maximum	**926731.660**	**260.000**	**4**
Range	**895064.884**	**252.000**	
Mean	286487.711	35.044	
Mean absolute deviation	138981.646	24.645	
Median absolute deviation	109400.076	8.000	
Standard-error	27759.543	6.636	
Lower bound Mean CI	230542.028	21.670	
Upper bound Mean CI	342433.394	48.419	

In the table 3 we show the microfiber pollution level classifications of beaches zones, respecting the microfiber volume and numbers. The classification is displayed with the colours of the Duncan's post hoc test groupings.

Tabel 3. Microfiber pollution level classifications of beaches zones

Volume(µm^3)				
Categories	**Mean**	**Grouping**		**OPL**
Mamaia_N	**542610.928**	**A**		**4**
EforieN_S	**479146.456**	**A**	**B**	**4**
EforieS_S	**429664.196**	**A**	**B**	**4**
Mamaia_S	**415999.415**	**A**	**B**	**4**
Mamaia_C	**394105.100**	**A**	**B**	**4**
Costinesti2_N	**336645.657**	**A**	**B**	**3**
EforieN_N	**265625.063**	**A**	**B**	**3**
Costinesti2_S	**263050.355**	**A**	**B**	**3**
EforieS_N	**229136.171**	**A**	**B**	**2**
EforieN_C	**221823.305**	**A**	**B**	**2**
Costinesti2_C	**187113.456**	**A**	**B**	**2**
Costinesti1_S	**167964.068**	**A**	**B**	**2**
Costinesti1_C	**157405.293**	**A**	**B**	**1**
Costinesti1_N	**150662.035**	**A**	**B**	**1**
EforieS_C	**56364.166**		**B**	**1**

Number				
Categories	**Mean**	**Groupings**		**OPL**
Mamaia_S	**180.33**	**A**		**4**
Costinesti2_S	**65.67**		**B**	**4**
Costinesti2_N	**43.00**		**B**	**4**
Costinesti2_C	**28.67**		**B**	**3**
EforieS_S	**28.33**		**B**	**3**
Costinesti1_N	**26.67**		**B**	**3**
Costinesti1_S	**21.33**		**B**	**3**
Mamaia_N	**20.67**		**B**	**2**
Costinesti1_C	**20.33**		**B**	**2**
EforieS_C	**20.00**		**B**	**2**
Mamaia_C	**16.67**		**B**	**2**
EforieN_S	**15.33**		**B**	**1**
EforieN_N	**15.33**		**B**	**1**
EforieS_N	**13.67**		**B**	**1**
EforieN_C	**9.67**		**B**	**1**

In the next table (4) we will show the descriptive statistics for the factor: beach location, for the variables: number and volume of microplastics and the Descriptive statistics for one-way ANOVA with the factor: beach location, for the variables: average volume and number of microfibers (table 5).

Table 4. Descriptive statistics for the factor: beach location, for the variables: number and volume of microplastics.

	Costinesti 1	**Costinesti 2**	**Eforie S**	**Eforie N**	**Mamaia**
Number of values	3	3	3	3	3
Mean	**158677**	**262270**	**238388**	**322198**	**450905**
Std. Deviation	**8721**	**74769**	**186822**	**137674**	**80170**
Std. Error	5035	43168	107862	79486	46286
Lower 95% CI of mean	137013	76534	-225701	-19802	251752
Upper 95% CI of mean	180341	448006	702478	664199	650059
Coefficient of variation	5.50%	28.51%	78.37%	42.73%	17.78%

	Costinesti1	**Costinesti2**	**EforieS**	**EforieN**	**Mamaia**
Number of values	3	3	3	3	3
Mean	**22.78**	**45.78**	**20.67**	**13.44**	**72.56**
Std. Deviation	**3.405**	**18.66**	**7.356**	**3.271**	**93.36**
Std. Error	1.966	10.77	4.247	1.889	53.90
Lower 95% CI of mean	14.32	-0.5653	2.394	5.318	-159.4
Upper 95% CI of mean	31.24	92.12	38.94	21.57	304.5
Coefficient of variation	14.95%	40.75%	35.59%	24.33%	128.67%

Table 5. Descriptive statistics for one-way ANOVA with the factor: beach location, for the variables: average volume and number of microfibers.

	Volume (μm^3)	Number	OPL
No. of values used	15	15	
Minimum	**123030.833**	**9.667**	
1st quartile	**167964.068**	**15.333**	**1**
Median	**263050.355**	**20.667**	**2**
3rd quartile	**415999.415**	**28.667**	**3**
Maximum	**542610.928**	**180.333**	**4**
Range	419580.095	170.667	
Mean	290932.155	35.044	
Mean absolute deviation	113677.176	24.516	
Median absolute deviation	105645.062	6.000	
Standard-error	34364.827	10.980	
Lower bound Mean CI	217226.931	11.494	
Upper bound Mean CI	364637.379	58.595	

In the next table (6) we show the microplastics pollution level classification of beaches, respecting the volume and number of microfibers. The classification is displayed with the colours of the Duncan's post hoc test groupings.

Table 6. Microplastics pollution level classification of beaches, respecting the volume and number of microfibers

Categories	Mean (μm^3)	Groupings		OPL
Mamaia	**450905.14**	**A**		**4**
EforieN	**322198.27**	**A**	**B**	**3**
Costinesti2	**262269.82**	**A**	**B**	**3**
EforieS	**260610.40**	**A**	**B**	**2**
Costinesti1	**158677.13**		**B**	**1**

Categories	Mean	Groupings	OPL
Mamaia	**72.56**	**A**	**3**
Costinesti2	**45.78**	**A**	**3**
Costinesti1	**22.78**	**A**	**3**
EforieS	**20.67**	**A**	**2**
EforieN	**13.44**	**A**	**1**

The results presented in table 6 show two groups (A and B) for the beach zones and just one for the beaches generated by Tukey post hoc test from the one-way ANOVA test. Between the beaches: Mamaia and Costinesti1, there is statistical significant difference (P=0.042) of the microplastics volume; the other zones presents no statistical differences between the microplastics volume values. Between all five beach locations, there are present no statistical differences between the microplastics number values. Microplastics volume for Mamaia beach has the highest pollution value and it is almost three times higher than the lowest pollution value of Costinesti1 beach. The number of microplastics from Mamaia beach has the highest pollution value and it is six times higher than the lowest pollution value of the Eforie N beach zone. Results from table 7 about the beach location microplastics pollution is in concordance with their geographical

distribution, from north to south. This is emphasizing the conclusion that the northern beaches have higher microplastics pollution level then the southern ones.

Table 7. Microplastics overall volume and number L^p norm (p = 2.5)

Beach Zones	OPL_L^p
Mamaia_S	4
EforieS_S	4
Costinesti2_S	4
Costinesti2_N	4
Mamaia_N	4
Mamaia_C	4
EforieN_S	4
Costinesti2_C	3
Costinesti1_S	3
EforieN_N	3
Costinesti1_N	3
EforieS_N	2
EforieS_C	2
EforieN_C	2
Costinesti1_C	2

Beach	OPL_L^p
Mamaia	4
EforieS	3
EforieN	3
Costinesti2	3
Costinesti1	3

Previously was introduced the OPL (Ordinal Pollution Level) that classifies the level of the micro plastic pollution by volume and number. The answer for the environmental question: which beach zone or beach location has the highest/lowest micro plastic pollution, has one solution by calculating the L^p norm of the OPL's for microplastics volume and number:

$$OPL_{Lp} = [OPL_{Volume}{}^{p} + OPL_{Number}{}^{p}]^{-p} \qquad (1)$$

Values in table 7 are rounded to an integer, in order to get a categorical significance. Only three pollution levels (4 (severe), 3(high) and 2(average)) occurred for the beach zones and only two (4 (severe) and 3 (high)) for the beach location.

CONCLUSIONS

Marine pollution includes a wide range of sources and types of pollution, generating destructive effects on marine ecosystems, with negative impact on both the flora and the fauna. Oil spills, eutrophication, invasive species, persistent organic pollutants (POPs), heavy metals, acidification, radioactive substances, marine litter, overfishing and destruction of marine habitat are the main forms of

pollution affecting and destroying the marine environment. The research conducted in the paper in different areas of Romania, confirms the presence of micro plastic pollution in all locations studied, the level and dispersion of pollution varies depending on the location of the beach and on their take-ups during the summer. Thus, the highest degree of pollution was recorded in Mamaia, with an average of 218 plastic microfibers, followed by Costinesti, with an average of 137 plastic microfibers, both resorts being the most popular for tourists. The lowest level of pollution was recorded in North Eforie where the average does not exceed 40 plastic micro fibres.

Another cause of high pollution levels recorded on Mamaia beach is the sea currents that concentrate in the south line the waste coming from the Danube. The Black Sea deep currents carry large masses of water from the Danube towards the Bosphorus Strait and the circular surface currents transport water masses from Costineşti towards Mamaia. Research conducted with free floating buoys showed that two - three months are enough to carry any substance, pollutants, waste or bodies from one side of the sea to another.

REFERENCES

1. M., GORYCKA: *Environmental Risks of Microplastics, Faculties der Aard- en Levenswetenschappen, Vrije Universiteit, Stichting De Noordzee, pp.63-70 (2009);*

2. D. LITHNER: *Environmental and Health hazards of chemicals in plastic polymers and products, Department of Plant and Environmental Sciences, Faculty of Science, University of Gothenburg (2011);*

3. T. ZAHARIA, D. MICU, V. NITA, V. MAXIMOV, R. MATEESCU, A. SPINU, M. NEDELCU, G. GANEA, M. GOLUMBEANU, C. M. URSACHE, M. CRISTEA: *Preliminary Data on Habitat Mapping in the Romanian Natura 2000 Marine Sites,1776, Journal of Environmental Protection and Ecology, Volume 13, No3A (2013);*

4. R. SIRBU, T. ZAHARIA, A. M. BECHIR, G. LILIOS, S. NICOLAEV, F. N. RONCEA: *Important Characteristics of the Marine Environment of the Romanian Littoral Coast – Favourable for Pharmaceutical Utilizations, Journal of Environmental Protection and Ecology, Volume 13, No3A (2013);*

5. LANCU, V., . MITRITA, M.., PETRE, J., CRUCERU, L., *Analytical Investigation of Some Organic Compounds from Contaminated Areas with Petroleum Products, Journal of Environmental Protection and Ecology*, Volume 11, No 1, p. 27-35, (2010).