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MARINE DEBRIS MANAGEMENT IN THE ADRIATIC SEA: A CASE STUDY OF CROATIA

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Abstract

Marine debris is a growing global environmental challenge in shaping environmental policies on all scales of governance. Growing use of environmentally harmful materials such as plastic and policy inadequacies in addressing the issue worsen the situation. So far, the research only partially addressed economic effects of marine debris focusing mainly on its social and environmental impacts. Different studies have proved economic losses caused by the marine debris in various industries such as tourism, fisheries, aquaculture, and shipping. The Mediterranean region countries are particularly sensitive to the impacts of marine debris. Croatia, as a country bordering the Mediterranean Sea with the Adriatic being its strategic development resource is suitable for the analysis of the marine debris issue. This article deals with economic impacts of marine debris and proposes strategic guidelines for future sustainable management of the Adriatic Sea to the benefit not only of Croatia, but of all the countries concerned.

Keywords: *marine debris management, environmental policy, economic impacts, neighbouring cooperation, European Union, the Mediterranean, Adriatic Sea, Croatia*

1. INTRODUCTION

Accumulation of marine debris has become one of the most growing global environmental threats for coastal and marine environments (European Commission, 2016a). The quantities of debris polluting seas and oceans all over the world are constantly rising. In 1997 it was estimated that 6.4 million tons of debris reach oceans and seas every year while recent estimates reveal that this amount has risen to 10 million tons per year (United Nations Environment Programme, 2005; European Environmental Agency, 2016). Increased amounts of marine debris all over the globe are to a great extent a result of growing plastic production and consumption which makes plastic a major component of the marine debris. In some

cases, plastic debris makes up to 95% of the total marine debris found in coastal and marine areas (Bergman M., Gutow L., Klages M., 2015).

In the business-as-usual scenario it is expected that the global production of plastic by 2050 will reach 33 billion tons which is 110 times more than the global production of plastic recorded in 2014 (Petricioli, D., Bakran-Petricioli, T., 2012; Rochman, C. M., et al., 2013). Analyses of marine debris sources show that anthropogenic land-based activities like landfilling, industrial and agricultural production, tourism and recreation are responsible for up to 80% of the total quantities of marine debris (European Commission, 2016a). Thus, the efforts on all the levels are directed at preventing land-based waste, which is the most desirable behaviour in the universally accepted waste management hierarchy. According to the waste management hierarchy, most to least preferred methods of dealing with waste include: 1. avoidance/prevention, 2. resource recovery (re-use, recycle, reprocessing, energy recovery), 3. treatment and disposal. Waste that cannot be prevented should be reused or recycled to avoid the loss of valuable materials, which is in line with the concept that has been popularized as "closed loop" or "circular economy".

Marine debris is defined as "any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment" (United Nations Environment Programme, 2009). Negative effects of the marine debris on marine economies are multifold. They range from reported cases of entanglement and ingestion of discarded or lost items by various marine organisms (Bergman M., Gutow L., Klages M. (eds.), 2015), health hazards and coastal landscape degradation (Columbia University, 2005) as well as negative economic implications which have so far been the least researched aspect of marine debris (United Nations Environment Programme, 2009; Lee, J., 2014).

There is scarce literature on economic costs imposed to societies due to prevalence of marine debris (McIlgorm, A., Campbell, H.F. and Rule, M.J., 2008). Most of the research conducted so far distinguishes between direct and indirect costs connected to marine debris (McIlgorm, A. and Campbell, H., Rule M., 2011). Direct costs of marine debris manifest in value of the damage directly caused by marine debris or in the form of lost revenues. A study conducted in the region of Asia-Pacific Economic Cooperation (APEC) revealed that in 2008 the total marine debris damage in the fishing, shipping and tourism, the three most important marine economy sectors for the region, reached US$ 1.265 billion (McIlgorm, A., Campbell H.F. and Rule M.J., 2008).

Municipalities have also reported about significant costs incurred due to cleaning up littered beaches and repairing fishing equipment. These costs can reach € 18 million per year for cleaning littered beaches, as reported by municipalities in the United Kingdom, and € 800,000 per year for repairing fishing nets, as reported by the municipalities from Sweden (German Federal Environmental Agency, 2013). A case from New Jersey where in 1988 between US$ 379 million and 3.6 billion were lost in tourism and other related industries is a good example of how detrimental economic consequences of marine debris can become (Debris Free Oceans, Inc., 2016). On the other hand, indirect costs related to marine debris are not easily identified and therefore cannot be precisely calculated. One of the examples refers to potential health costs if microplastics in oceans and seas enter food chain. This problem, however, requires further analyses as current research on this topic has been modest (Environmental Health Perspectives, 2015).

Amongst the key factors hampering efficient marine debris management is a lack of coordinated strategic approach in dealing with the problem and inefficient enforcement of programs, regulations and standards on all the levels of governance (United Nations Environment Programme, 2009). This article aims to contribute to understanding of how improved strategic management of marine debris can improve preservation of marine environment. The Republic of Croatia was selected as a case study for several reasons.

Firstly, tourism attractiveness of the Adriatic Sea has traditionally been the key factor in generating tourism traffic, which accounts for 18% of the national gross domestic product (GDP) (Ministarstvo turizma, 2016).

Secondly, as a fully-fledged European Union (EU) member state (MS), Croatia has the obligation to transpose and implement the EU Marine Strategy Framework Directive (MSFD) which stresses the need to achieve good environmental status of marine waters in the EU by 2020 (European Parliament, 2008). Meeting the objectives of the Directive is a challenging process for Croatia. Difficulties are most evident in the process of developing a national strategy for marine environment protection, which has not yet been adopted, even though its implementation should have started as early as in 2016. This implies that marine environment preservation is still low on the list of the national environmental and political priorities even though the Adriatic Sea with its coastline is one of the strategic development resources for the country. Most recent initiative aimed at sustainable valorisation of marine resources relates to The Three Seas Initiative, an informal political platform for strengthening cooperation among the EU Member States situated between the Adriatic, Black and Baltic Seas.

2. GLOBAL INITIATIVES RELATED TO MARINE DEBRIS PROBLEM

Attempts to deal with the problem of marine debris on a global level include binding international conventions, public awareness and clean-up campaigns and voluntary agreements initiated by the most prominent global environmental actors. The United Nations Environment Programme (UNEP) and the EU stand out as the leading global actors in the field of marine debris prevention and clean-up. Since 1980s regulation efforts were also accompanied by the growing research interest in the problem of marine debris.

By the 1990s most of the threats and impacts related to marine pollution were well understood. However, it has not resulted in diminishing the quantities of marine debris. Just the contrary, new threats for marine environments have appeared over time with the production and use of new and environmentally harmful materials such as different kinds of plastic. As negative trends continually rise, tackling marine debris has never been a greater challenge for the global environmental actors. Globally, ingestion or entanglement of marine debris items has been observed on a minimum of 267 different marine organisms, which is a huge loss for marine ecosystems (Greenpeace, 2006).

Marine debris is also responsible for the loss of ecosystem services such as food provision and entry of alien invasive species, which can severely disrupt balance in marine habitats and ecosystems (Bergman M., Gutow L., Klages M. (eds.), 2015). Risks on human health and safety that might occur due to dangerous items discarded on beaches or if vessels' engines get entangled in marine debris floating under the sea surface are considered as having serious social impact (Columbia University, 2005).

Most important international treaties aimed at protecting oceans and seas from sea-based sources are the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention, in force since 1975) and the International Convention for the Prevention of Pollution from Ships (MARPOL, in force since 1983). Since 1990s focus was shifted on land-based activities as research has shown that land-based sources are the origin of 80% of marine debris (European Commission, 2016a). In that context, the UNEP has stood out as the leading initiator of preventing and reducing marine debris from land. Under its auspices in 1995, The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities was initiated and became the biggest inter-governmental agreement on preserving marine and coastal environments.

The Programme is operationalized through a range of regional seas action plans, conventions and protocols, also initiated by the UNEP (e.g. the four European Regional Seas Conventions) (United Nations Environment programme, 2014b). The UNEP promotes marine debris problem by incorporating it in the agenda of the key international environmental conferences such as those held in Rio de Janeiro in 1992 and 2012 and by hosting events specifically addressing the issue of marine debris (e.g. The Fifth International Marine Debris Conference (Honolulu, 2011)). Importance of the marine debris issue was also confirmed in the new UN's global development agenda until 2030. For the first time it included a specific goal (Goal 14) (United Nations, 2017) devoted to the problem of marine debris.

New initiatives by some other global actors have recently appeared, mostly as a result of a growing threat of plastic for marine environment. In this context, efforts of the Ellen MacArthur Foundation (2017), aimed at improving marine environment through circular economy, are of particular importance. All global anti marine debris initiatives aim at achieving the same goal which is to reduce levels and negative impacts of marine debris worldwide on economies, ecosystems and animal and human welfare.

2.1 Overview of the marine debris problem in the European Union

There are 23 EU member states with sea coast on four seas and one ocean, i.e. the Mediterranean Sea, the Baltic Sea, the North Sea, the Black Sea and the Atlantic Ocean. The EU coastal areas have a population of nearly 41% of the total EU population and cover around 40% of the overall EU territory. Those data referring to 2011 excluded Croatia, who became a member state in 2013. If compared to non-coastal regions of the EU, its coastal areas often benefit from more favourable economic indicators such as higher GDP per capita and higher employment rates (Eurostat, 2015). Positive economic performance can be directly linked to the comparative advantages coastal regions gain from their marine resources and ability to develop unique economic activities such as tourism, fishery and aquaculture, maritime transport and manufacturing, etc.

The Mediterranean region stands out as the most visited tourism region in Europe as well as the most populous of all the EU coastal regions (Eurostat, 2015). At the same time, urbanization and tourism are the key reasons of marine debris issue in the Mediterranean region with plastic having the greatest share of 83% (Galgani, F., Hanke G., Werner S. and De Vrees L.,2013). Plastic has also been a prevalent form of marine debris in other European seas (e.g. 75% in the North Sea, and 80% in the Baltic Sea) (Galgani, F., Hanke G., Werner S. and De Vrees L., 2013); Stockholm Environment Institute, 2016). Another factor caused by the global climate changes that could relate to the problem of marine debris must be at least mentioned here, i.e. sea level rising (SLR) (Fraile-Jurado, 2018). The SLR contributes to the spreading of marine debris and consequently might seriously affect the coastline tourism development. Population and tourism in the coastal regions are expected to grow in the future. It is expected that the number of seasonal tourists only in the Mediterranean region will reach the number of 235 to 350 million in 2025 while the number of resident populations in the Mediterranean basin is projected to be between 520 and 570 million in 2030 (Hinrichsen, D., 2013). This implies that anti-marine debris policy will continue to be one of the key topics within the EU environmental policy.

The MSFD was adopted in 2008 as the first legislative act aimed to directly protect marine environment across the EU (European Parliament, 2008). Previously, this marine litter issue was tackled only indirectly within the EU regulation related to waste and water management (European Commission, 2016b; 2016c). The 7th Environmental Action Programme to 2020 (EAP) (European Commission, 2013), as the key EU's environmental protection strategy

until 2020, is instrumental for achieving goals of the MSFD. Sectoral documents related to resource efficiency and waste management more concretely address the marine debris issue**.** In this context, most important efforts by the European Commission (EC) include adoption of the Europe 2020's Flagship Initiative Resource Efficient Europe (European Commission, 2011a) with the Roadmap to a Resource Efficient Europe (European Commission, 2011b) and Circular Economy Package adopted in 2015, which introduced more stringent stipulations of the waste regulation.

An extensive on the implementation of the Circular Economy Action Plan was adopted on March 4, 2019 (European Commission, 2019). The first ever EU Plastic Strategy, aiming to "protect the environment from plastic pollution whilst fostering growth and innovation, turning a challenge into a positive agenda for the Future of Europe," was adopted on January 16, 2018 (European Commission, 2018).

3. MARINE DEBRIS MANAGEMENT IN THE REPUBLIC OF CROATIA

Marine debris management in Croatia has not yet been developed. The research on this issue, intensified in the last ten years, pointed out the cases of significant marine pollution, with urbanization and tourism being the key sources of pressure for marine environment. Adriatic Croatia covers 22% of the Croatian territory and, according to the 2011 Census, has a population of 1,411,000 inhabitants (25.6% of the entire population of Croatia).

In 2015 there were 12,508,905 tourist arrivals (87% of total tourist arrivals in Croatia) and 68,299,167 tourist nights (95% of the total tourist nights in Croatia) recorded in the Adriatic Croatia (Croatian Bureau of Statistics, 2016). The greatest risks arise from landfills in the coastal areas, particularly due to illegal landfills and very low rates of reuse and recycling of collected household waste. In 2012 there were around 600,000 tons of household waste produced in the Adriatic Croatia which equals 40% of the total household waste produced in that year in Croatia.

At the same time share of household waste sent for reuse was 5.8% on average, which is significantly lower than the national average (14.8%). The share of collected household waste sent for reuse ranged from 1.1% in Split-Dalmatia County to 14.4% in Primorje-Gorski Kotar County (Ekonomski institut i Ekonomski fakultet Split, 2015). Inadequate sewage systems and river estuaries are also considered a significant land-based sources of marine debris in Croatia (Kwokal, Ž., Štefanović, B., 2009). The case of Kaštela Bay in the area of the city of Split is a good example of severe negative effects that obsolete sewage systems can have on marine environment. Until 2005, around 4.4 million m^3 of wastewater were discharged into the bay every year, without prior treatment.

It was later confirmed as being the cause of high eutrophication of the sea in the bay, changes to plankton and severe mortality of fish (Rochman, C. M. et al., 2013). Composition of marine debris has not been systematically analysed. However, some research results reveal huge amounts of plastic in bays and coves of great ecological values. Kwokal and Štefanović (2009) identified 70-90% of plastic in the total amount of marine debris found in the bays on the islands of Lastovo, Korčula and Mljet while Petricioli and Bakran-Petricioli (2012) recorded hundreds of plastic items on the islands of Vis, Dugi Otok and in the Zadar canal (Kwokal, Ž., Štefanović, B., 2009; Petricioli, D., Bakran-Petricioli, T., 2012). Maritime transport stands out as the most significant sea-based source of marine debris in the Adriatic Croatia.

Reported cases on waste pollution from ships have increased 2.2 times in the period from 2005 to 2010 (Institut za oceanografiju i ribarstvo, 2012). Ships are also responsible for releasing 2.5 million of cubic meters of ballast waters in the Croatian part of the Adriatic Sea

every year (Ministarstvo, mora, prometa i infrastrukture, 2012). Tourism and irresponsible fishing practices are also considered as significant threats.

However, a more extensive research is needed to make reliable conclusions about the link between those activities and marine debris. In 2010, the biggest ecological incident occurred when the Mljet canal was polluted by debris from Albania causing more than € 100,000 of costs for its removing and clean-up (Dubrovačko-neretvanska županija, 2011). This point us another highly important feature of marine debris and that is its transboundary nature, which requires a more coordinated cooperation of Croatia with other countries in the Adriatic region. In Croatia marine debris is incorporated in the legal and strategic documents related to sustainable waste management. The umbrella Act on Sustainable Waste Management (OG 94/13) states that marine debris, as a special waste category, should be regulated by a special bylaw. However, such bylaw has not yet been drafted. Similarly, there is no specific strategic document for marine debris management. In the Waste Management Strategy (OG 130/05) and Waste Management Plan that was in force until 2015 (OG 85/2007), marine debris is a sporadic issue, mentioned briefly and only from the perspective of waste management in ports. With the adoption of the Waste Management Plan for the period 2017-2022, for the first time a specific objective related to marine debris was introduced, supported by specifically defined measures and financial resources (Vlada Republike Hrvatske, 2017). By transposing stipulations of the EU MSFD into the national legislation, Croatia has undertaken an obligation to develop national strategy for marine environment protection by 2015. The strategy has not yet been finalized because the key implementation document, i.e. the National Programme of Measures, has not yet been adopted. Reasons for such delay include various factors such as institutional weaknesses as well as lack of financial resources. In the years to come, the key environmental challenges for Croatia will include improvements of the waste management system, particularly in regard to achieving recycling goals, extending the NATURA 2000 ecological network to marine areas and more stringent implementation of the Urban Wastewater Treatment Directive (91/271/EEC) (Europska komisija, 2017). Croatia's success in dealing with those challenges will also determine its ability to control the key marine debris sources.

3.1 Economic analysis of marine debris management in Croatia

Extensive economic analyses of marine debris issue in the Adriatic Croatia have not yet been conducted, mostly due to the lack of data in the sectors that are either the cause of marine debris or are affected by it. Despite the data limitations, a cost-benefit analysis has been made in order to examine whether future investments in the Adriatic Sea preservation are justified and to what extent. The analysis was conducted in several steps.

Firstly, it was assumed that land-based non-hazardous household waste was the main risk for marine debris in the Adriatic Croatia. During the peak of tourism season in July and August amounts of generated non-hazardous household waste dramatically rise due to number of tourists which by far exceeds the number of local population. Thus, another assumption was that months of July and August could be considered as the period with the highest risk of land-based household waste entering the Adriatic Sea and becoming marine debris. Following this, total costs of waste management that is potentially the biggest source of marine debris were calculated as the sum of costs for managing non-hazardous household waste generated by the local population and tourists during July and August (approximately € 40 million).

On the other hand, estimation of benefits was conducted on the basis of available data in the relevant sectors and under the assumption of ideal scenario in which marine debris is completely avoided. In calculating benefits, the focus was on local public budget savings and

revenues in the sectors of fisheries and tourism. If there were no marine debris, local public budget savings would reflect in no expenditure and investments in the sectors of wastewater and waste management, which are the biggest potential source of marine debris.

As for the sectors of fisheries and tourism, avoidance of marine debris would mean sustaining stable revenues from fish export and tourism traffic. Overall, total sum of benefits in those three sectors in July and August would amount to around € 2.5 billion. The cost-benefit analysis (Čermak, H., 2016) shows that it is justified to allocate financial resources to preserve and protect the Adriatic Sea as the loss of benefits due to marine debris would significantly exceed costs needed for its avoidance.

3.2 Proposals for new strategic guidelines for controlling marine debris in Croatia

It should be noted that strategic guidelines are the results of the project Derelict Fishing Gear Management System in the Adriatic Region (DEFISHGEAR project), implemented in the seven countries of the Adriatic Region (Albania, BiH, Croatia, Montenegro, Greece, Italy, Slovenia) and financed under the IPA Adriatic Programme in the period from 2013 until 2016. This project proves that the neighbouring and regional cooperation in the time when the meaning of the term 'border' changes due to new trends in international cooperation is of key importance (Conti Puorger, 2013). The cooperation not only among EU member states but between EU member states and the so called third countries in preserving the Adriatic Sea as well as the Mediterranean as a whole is indispensable.

Various land and sea based marine debris sources seriously threaten to pollute the Adriatic Sea. Marine debris is a risk for preservation of the Adriatic Sea ecosystems and their ecological functions as already proven by some previously conducted research (Kwokal, Ž., Štefanović, B., 2009; Petricioli, D., Bakran-Petricioli, T., 2012). Also, marine debris is a significant threat for losing economic benefits Croatia gains from the Adriatic Sea. In 2015 revenues generated from tourism reached € 9.5 billion, which to a great extent can be attributed to tourism attractiveness of the Adriatic Croatia (Ministarstvo turizma, 2016). If revenues generated from other activities were added, i.e. fisheries, aquaculture, maritime transport, economic benefits would be even bigger. At the same time, Croatia is not doing enough to give the Adriatic Sea a strategic importance within the national environmental policy. There is a variety of weaknesses that need to be eliminated in order to create efficient marine debris tackling strategic framework.

First and foremost, establishing a system of continuous and reliable marine litter monitoring should be a top priority as the lack of it hinders preparation of the effective anti-marine debris strategy and quality decision making. This is particularly important regarding transboundary nature of marine debris, which means that it cannot be efficiently tackled without exchange of harmonized data between the neighbouring countries. Furthermore, credible regional databases are a prerequisite for joint regional projects, which can significantly contribute to efficient marine debris management in the Adriatic region. Marine debris originates from different sources that can be identified and controlled only if coordinated and transparent multi-sectoral cooperation is established. Ministry of Environmental Protection and Energy is responsible for developing anti-marine debris strategy. However, other relevant ministries managing sectors important for the problem of marine debris cannot be left out of the process (e.g. Directorate of Fisheries within the Ministry of Agriculture, the Ministry of Sea, Transport and Infrastructure). Further efforts are thus needed in establishing coordinated horizontal cooperation that will enable tackling marine debris from all sources. In order to give marine debris well-deserved higher priority status on the overcrowded national environmental agenda, capacity building of the relevant national ministries should also be considered.

It is worth noting that marine debris is not highly prioritized in the general waste management strategic framework. Within that framework, marine debris has so far been treated merely as a sub-theme which undermines its importance and postpones adequate actions. Land-based activities, as the main source of marine debris, should be more effectively controlled within the national waste management policy. Amongst other things, this requires systematic planning of investments in waste infrastructure and a more stringent enforcement of circular economy principles. Ignoring marine debris can cause significant costs for marine economies, as shown by the example of the APEC economies or debris pollution in the Mljet canal. Improvements in the legislative and strategic framework should thus be accompanied by systematic planning of the prevention measures such as awareness raising activities.

Measures like information boards, signage and clean-up campaigns are relatively inexpensive and, if applied systematically, can give positive outcomes in the form of avoiding marine debris, lowering/eliminating environmental costs for coastal areas and strengthening collective environmental awareness. Growing issue of marine debris and its environmental, social and economic implications justify the necessity to position this problem higher on environmental agendas on all the levels of governance. Establishing reliable, scientifically based monitoring systems is the first step in this process and a prerequisite for all further actions. Another challenge is to achieve harmonization of data within all coastal regions in order to efficiently tackle the transboundary nature of the marine debris.

Along with this, strategic and legislative frameworks for management of the sectors relevant for the marine debris issue (e.g. waste and water management, maritime activities, fishery, tourism, etc.) need to be more ambitious in order to contribute to prevention and removal of marine debris. This relates to setting up more ambitious goals, particularly in the waste management sector, but even more to effective implementation of such goals. Last but not least important, "soft" measures such as awareness raising campaigns should not be neglected as they have proven to be affordable and effective instruments in preventing and removing marine debris. Croatia is still at the beginning of the process of establishing an effective strategic and institutional framework for dealing with the marine debris issue. Obstacles have been identified in all the phases of this process, from data collection and monitoring to actual development of the adequate framework.

More efforts will have to be undertaken by all relevant actors on all the levels to scale up marine debris issue on the national environmental agenda. This will determine Croatia's success in complying with the marine policy goals of the European Union and it will also affect future management of the Adriatic Sea as one of the key development resources for the country.

4. CONCLUSIONS

Marine debris accumulation being one of the global environmental threats causes not only social and environmental problems but also serious economic effects to the countries concerned. It is detrimental to marine economies whose tourism, fisheries, aquaculture and shipping are their strategic development resources. The economic impacts of marine debris should be approached far more seriously and strategic guidelines for future sustainable management of the seas are indispensable.

Croatia, with its Adriatic coastline, being a Mediterranean country as well as a member state of the European Union still lacks adequate strategic framework for marine debris management. The European Union documents regulating the issue should serve as starting guidelines to shape an efficient anti-debris strategy. Taking into consideration the importance of the marine debris transboundary nature, it is clear that a successful strategy, apart from the

efforts of a particular country also requires a 'transboundary' cooperation of all countries in the region. The results of the analysis of the state of the art in Croatia in the field of strategic tackling of the marine debris management issue are applicable to the countries with similar problem. Thus, in order to prevent economic losses caused by the lack of a strategic framework the following measures are necessary: the establishment of a continuous and reliable marine litter monitoring; the establishment of credible regional databases; harmonization of data within all coastal regions, well established multi-sectoral cooperation (including joint action by several relevant ministries); coordinated horizontal cooperation tackling marine debris from all sources; systematic planning of investments in waste management infrastructure based on circular economy principles; intensive awareness raising activities. The measures in Croatia undertaken so far should achieve favourable results so that it will manage to provide the envisaged strategic framework in compliance with the European Union marine policy in joint efforts to contribute to preservation of the Adriatic Sea and the economic value it has as development resource for Croatia and all the countries of the region.

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