JOINT INNOVATIVE MONITORING TO REDUCE NONPOINT SOURCE POLLUTANT AND LITTER IN THE BLACK SEA

[1]GEORGE N. ZAIMES, [2]PASCHALIS KOUTALAKIS, [3]GEORGIOS GKIATAS, [4]VALASIA IAKOVOGLOU, [5]MIRELA MARINESCU, [6]OANA RISTEA, [7]ECATERINI KUHARUK, [8]ILYA TROMBITSKY, [9]MUSTAFA TUFEKCIOGLU, [10]MEHMET YAVUZ, [11]AYDIN TUFEKCIOGLU, [12]AHMET DUMAN

[1,2,3,4]GERi Lab, Department of Forestry and Natural Environment Science, International Hellenic University, 1st km Drama-Microchoriou, PC 65404, Drama, GREECE.
[5,6]River Basin Management Plan Office, Buzau-Ialomita Water Administration Strada Bucegi 20, PC 120208, Buzau, ROMANIA.
[7,8]Eco-TIRAS International Association of River Keepers, Teatrala 11A, Chisinau, PC 2012, REPUBLIC OF MOLDOVA.
[9,10,11,12]Faculty of Forestry, Artvin Çoruh University, Seyitler Yerleşkesi, Merkez 218A, Artvin, PC 08100, TURKEY.
E-mail: zaimesg@for.ihu.gr, viakovoglou@yahoo.com, koutalakis_p@yahoo.gr, ggiatas@emt.ihu.gr

Abstract - The Black Sea is considered one of the most degraded regional seas. Efforts have been made to improve the conditions of the Black Sea, but little focus has been on the inland pollutants and litter, specifically from the rivers and streams that end in the Black Sea. Streams and rivers are significant sources of sediment and litter. The study aimed to identify the primary sources of sediment and litter and their contributions. Such a database would water managers suggest the optimal nature-based solution to mitigate pollution sustainably. The study has five pilot areas in Greece, Romania, Armenia, Moldova, and Turkey. This allowed us to investigate different riverine ecosystems around the Black Sea and the implementation of different nature-based solutions. Surface and stream bank erosion methods are applied at different scales (plot and watershed) to estimate their contributions to the Black Sea. In addition, traditional (runoff plots erosion pins) and innovative methods (laser scanning, unmanned aerial vehicles) are utilized. In addition, microplastics in river sediment and water samples were investigated. The results allowed us to target areas with the highest erosion or litter, and the optimal nature-based solutions based on the specific characteristics of these areas to be implemented.

Keywords - Sediment, Plastics, Surface Erosion, Stream Bank Erosion, Nature-Based Solutions

I. INTRODUCTION

The depollution of semi-enclosed seas is difficult because of the significantly slower water circulation since water is only exchanged through narrow straights. The Black Sea is a circulates its water with the Mediterranean through the Dardanelles, Bosporus straits, and Sea of Marmara of Turkey. Therefore, because of the many anthropogenic pressures and limited circulations it is one of the most polluted regional seas [1]. Significant sources of pollution are litter and non-point sources (e.g., sediment and nutrients) [2, 3, 4, 5]. Mitigating such pollutants has focused on marine or coastal environments despite rivers and their tributaries being major contributors [6]. Large rivers, such as Danube, Dnieper, Southern Bug, Dniester, Don, Kuban, Sakarya, etc., contribute approximately 300 km^3 yr^{-1} of discharge to the Black Sea that is around 4–5 times the basin's surface area [1]. These waters carry many pollutants that degrade the Black Sea [1]. The project "Protecting streams for the clean Black Sea by reducing sediment and litter pollution with joint innovative monitoring and control tools and nature-based practices - Protect-Streams-4-Sea" will enhance environmental protection in the Black Sea by reducing its pollutants and litter. This was accomplished by focusing on the river pollutants and litter transported to the Black Sea. In this paper, major results from the pilot areas are presented.

II. STUDY AREA

Parallel activities are being implemented in five Black Sea countries. The pilot areas in each country are a) the Aggitis River watershed in Greece, b) the Buzau River watershed and Siriu reservoir in Romania, c) Debed River watershed in Armenia, d) Baltata River watershed in Moldova, and e) Arhavi River watershed in Turkey (Figure 1). The water bodies of the pilot areaswith different characteristics to test the methodologies in different environments.

III. METHODS AND MATERIALS

Traditional with innovative methods were utilized to measure surface and stream bank erosion and microplastics. Specifically, at the plot scale, surface runoff plots and Gerlach traps were utilized for surface runoff and erosion pins, cross-section surveys, and laser scanning for stream bank erosion [7, 8]. To estimate surface and stream bank erosion at the watershed scale, remote sensing methodologies, geographic information systems, and hydrologic modeling were implemented [9]. Specific reaches were targeted, with Unmanned Aerial Vehicles

(UAVs) images to produce orthomosaics [10]. Finally, samples were collected to estimate the microplastics in selected water bodies.

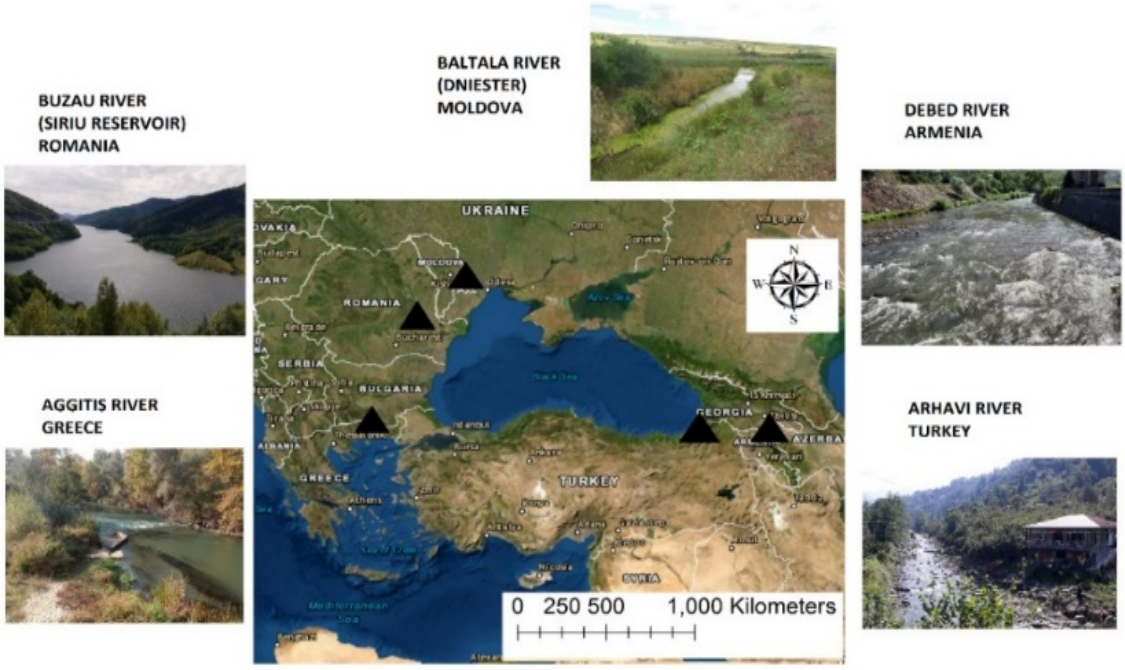


Figure 1. The project's pilot areas: Aggitis River watershed in Greece, Buzau River watershed and Siriu reservoir in Romania, Debed River watershed in Armenia, Baltata River watershed in the Republic of Moldova, and Arhavi River watershed in Turkey.

IV. MAIN RESULTS

A. Greek Pilot Area

Given the episodic and dynamic nature of river bank and bed erosion, along with the difficulty of reaching certain reaches, a methodological approach that uses aerial imagery from drones was developed and applied. Specifically, in the intermittent torrent channel Kallifitos in Greece two different flights (24 August 2022 and 23 October 2022) enabled us to capture the area in high detailed orthomosaics [10]. These products were analyzed and compared by developing the digital elevation model of differences—DoD (Figure 2). The methodology used was able to identify the location and the volume of the bed material extracted and the time frame in which it occurred. The comparison of the DoD showed that in area of 6329.41 m2 the volume of soil loss equaled to 5913.57 m3 (net loss). In contrast, in the area of 1658.70 m2, located at the west part of the captured image, a volume of deposits equal to 1032.91 m3 was deposited (net gained). The total extracted material was the subtraction of the previous numbers that resulted to 4880.66 m3. The specific stream reach "experiences" changes over time from natural geomorphologic changes but also from anthropogenic alterations.

B. Romania Pilot Area

The study investigated the presence of the fraction of plastic below 5mm, called MICROPLASTIC, or invisible plastic, which is the most hazardous to the environment and human health. This study is the first study in Romania, carried out on water samples (Figure 3) (studying microplastic in suspensions) and sediment from a reservoir. The origin of this fraction is the fragmentation by degradation of plastic waste under the action of water, waves, UV radiation and temperature variation. Water and sediment samples were analyzed microscopically to determine the abundance and type of fragments in the samples. Fragments of plastic were identified in all the samples. Then, plastic fragments were selected for FT-IR spectrophotometric analysis, which determined the type of polymers present in the chemical structure. This represents a fingerprinting analysis, identifying the POLYMER from which that microscopic fragment is made. Thus, the origin of the plastic fragment (to which plastic object it belongs) is found.

C. Moldavian Pilot Area

The focus of the project main efforts in Moldova was due two factors: (a) the high degree of soil erosion and small rivers' extreme pollution caused by intensive agriculture and their bad monitoring, and (b) the almost complete lack of awareness and experience in using innovative monitoring and control tools in this field. The goal was using the Remote Sensing techniques was to identify the erosion-prone areas, utilizing historical satellite monitoring. Two tasks were addressed: the implementation of vegetation indexes to map areas that are the most vulnerable to

soil erosion and use satellite images in the assessment of time trends in stream bank erosion. It was shown that above 8.4% of the Baltata River Basin is affected or exposed to erosion; the dominant erosion forms are landslides and gullies, occupying together 40% of erosion-prone areas. The time trends analysis highlighted a significant increasing trend in stream bank erosion (almost 80%), while very few sectors represented its decrease in 1985-2022 (Figure 4).

D. Turkish Pilot Area

n this study the analysis was done on the lateral and vertical changes in the stream network of the Arhavi River Watershed in Turkey. The orthomosaics and the digital terrain model (DTM) were built for the study area, by collecting images with a UAV DJI Matrice 300 RTK and utilizing the Pix4DMapper structure-from-motion software. As the basis layers for digitization, topographic maps from the 1960s and Google Earth photos from 2011, 2015, and 2017 were used. ArcGIS 10.8 was used to define the centerline (thalweg), left and right banks, alluvial bars, and active channel width. The Channel Migration Toolbox was used to evaluate the lateral morphological change. The vertical changes within and along the stream were evaluated using the CloudCompare program (Figure 5) and show case both deposition and incision during the time period.

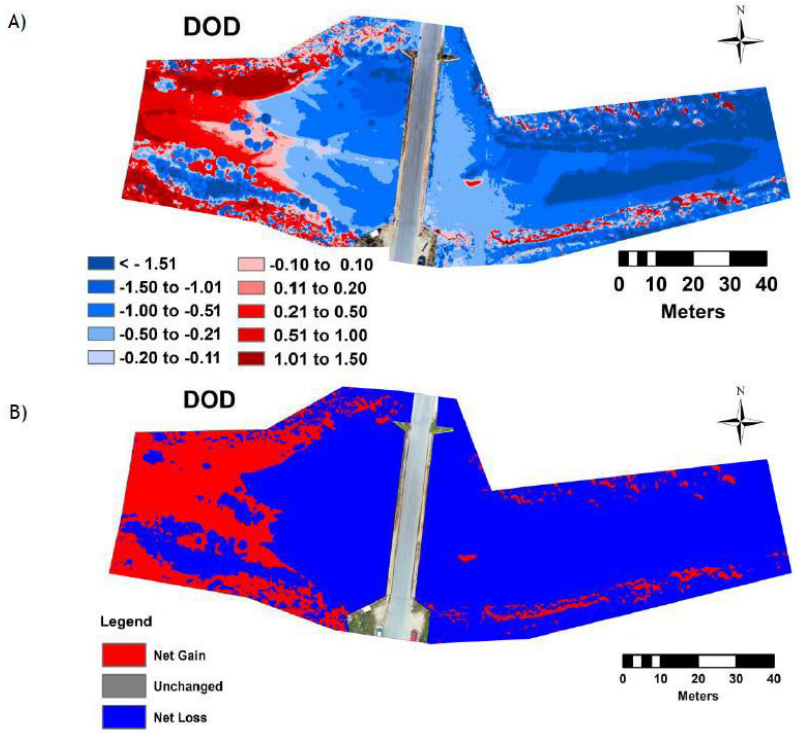


Figure 2. The DoD resulted from the comparison of the images between the dates 14 September 2022 (a) and 28 October 2022 (b). The colorized scale represents the different elevation categories (in meters). The 3 classes: (red) gained material, (grey) unchanged elevation and (blue) loss material.

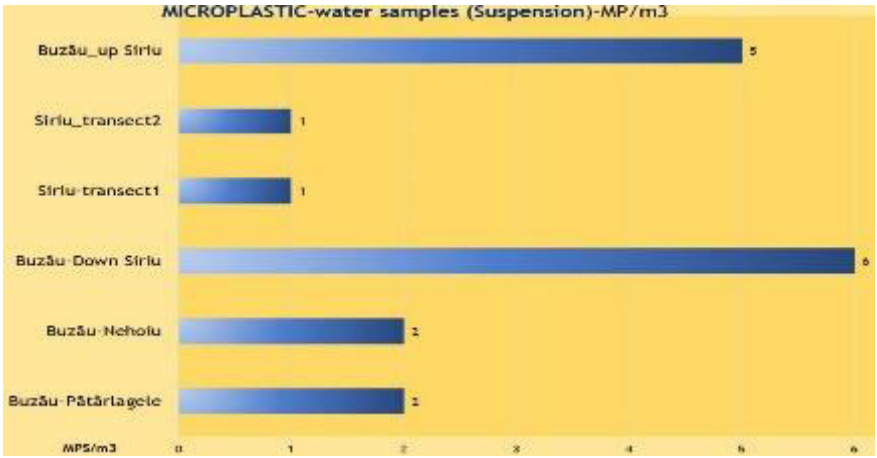


Figure 3. The microplastics in water samples collected in different location of the Siriu reservoir & Buzau River Basin.

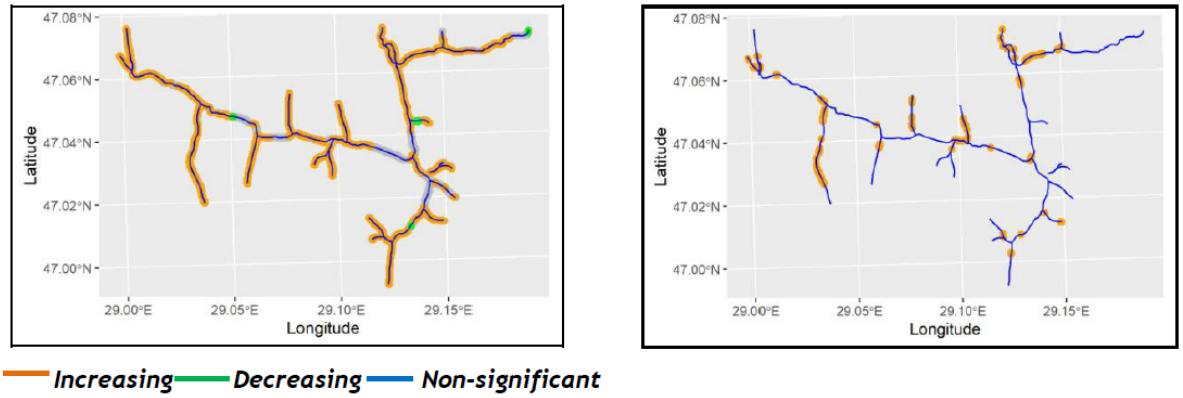


Figure 4. a) The Time trends in stream bank erosion of Baltata River, 1985-2022 and b) The sectors (in orange) within the Baltata River with a strong correlation between streams erosion and time.

V. CONCLUSIONS

Nonpoint source pollutants are degrading and negatively impacting the Black Sea. Through this study innovative and accurate methods to assess surface and stream bank erosion. These methods provide accurate estimates of erosion and deposition at large scales but also showcase areas that are more vulnerable to erosion. This allows the water or land manager to implement targeted best management practices. In addition, the project addressed another important issue microplastics. These are a major pollutant problem in the region and measures need to be implemented to mitigate them.

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