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Joint Innovative Monitoring to Reduce Nonpoint Source Pollutants and Litter in The Black Sea

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ABSTRACT

One of the regional seas with the worst degradation is the Black Sea. While efforts have been undertaken to enhance the Black Sea's environment, the inland pollutants and litter—more significantly, those from the rivers and streams that empty into the sea—have received less attention. Streams and rivers are significant sources of sediment and litter. The main goal of the study was to determine the main contributors of litter and silt as well as their sources. Such a database would help 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, uncrewed aerial vehicles) are utilized. In addition, microplastics in river remains 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

1.0 INTRODUCTION

The depollution of semi-enclosed seas is difficult because of the significantly slower water circulation since water is only exchanged through narrow straights. Through the Bosporus Straits, the Sea of Marmara in Turkey, and the Dardanelles, the Black Sea exchanges water with the Mediterranean. Therefore, because of the many anthropogenic pressures and limited circulations, it is one of the most polluted regional seas (Stanev & Ricker, 2019). Significant sources of pollution are litter and nonpoint sources (e.g., sediment and nutrients) (Berov & Klayn, 2020; Feldbacher et al., 2016; Cincinelli et al., 2021; Lechner et al., 2014). Mitigating such pollutants has focused on marine or coastal environments despite rivers and their tributaries being major contributors (Zaimes et al., 2019). Significant rivers, such as the Danube, Dnieper, Southern

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Bug, Dniester, Don, Kuban, Sakarya, and others, collectively supply approximately 300 cubic kilometres per year of water to the Black Sea. This discharge is roughly four to five times the surface area of the Black Sea's basin. Unfortunately, these waters transport a variety of pollutants, contributing to the degradation of the Black Sea. (Stanev & Ricker 2019) Enhancing environmental protection in the Black Sea by lowering pollutants and litter is the goal of the "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" project. This was accomplished by focusing on the river pollutants and litter transported to the Black Sea. In this paper, significant results from the pilot areas are presented.

2.0 METHODOLOGY

2.1 Study area

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

Traditional and 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 (Zaimes et al., 2011; Vatandaşlar & Yavuz, 2017). To estimate surface and stream bank erosion at the watershed scale, remote sensing methodologies, geographic information systems, and hydrologic modelling were implemented (Koutalakis et al., 2020). Specific reaches were targeted, with Unmanned Aerial Vehicles (UAV) images to produce orthomosaics (Gkiatas et al., 2022). Finally, samples were collected to estimate the microplastics in selected water bodies.

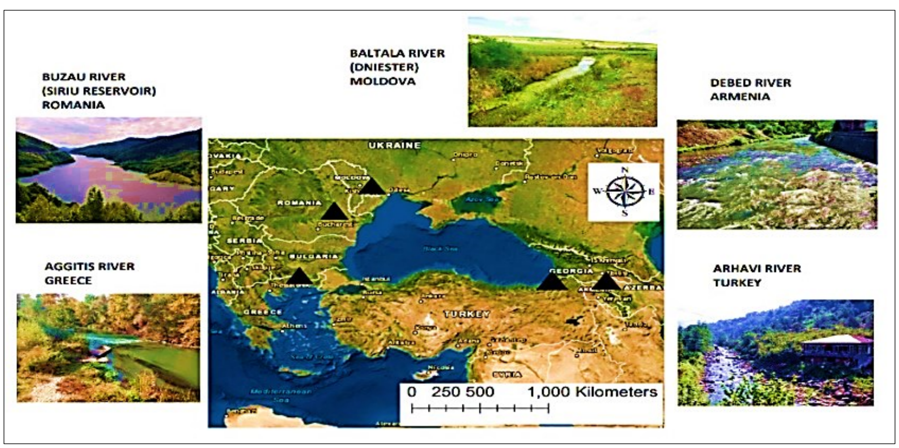

Figure 1: The project's pilot areas: Aggitis River watershed in Greece, Buzau River watershed and Siriu reservoir in Romania, Debed River watershed in Armenia, Baltata River watershed in the Republic of Moldova, and Arhavi River watershed in Turkey.

3.0 RESULTS AND ANALYSIS

3.1 Greek Pilot Area

To address the periodic and ever-changing nature of river bank and bed erosion, as well as the challenges associated with accessing certain areas, a methodological approach utilizing aerial imagery captured by drones was developed and implemented, specifically in the intermittent torrent channel Kallifitos in Greece's two different flights (24th August 2022 and 23rd October 2022) enabled us to capture the area in high detailed ortho mosaics (Gkiatas et al., 2022). The digital elevation model of differences, or DoD, was created after these products were examined and contrasted Figure 2. The location, amount, and timing of the bed material extraction were all determined by the employed approach. According to the DoD comparison, the volume of soil loss in an area of 6329.41 m2 was equal to 5913.57 m3 (net loss). In comparison, a volume of deposits equal to 1032.91 m3 (net gained) was deposited in the region of 1658.70 m2, which is situated in the western portion of the image that was taken. After deducting the earlier figures, the total removed material reached 4880.66 m3. The particular stream reach "experiences" changes over time due to both anthropogenic and natural geomorphologic changes.

3.2 Romania Pilot Area

The study investigated the presence of a 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 lake. 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 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 the plastic object belongs) is found.

3.3 Moldavian Pilot Area

The focus of the project’s primary efforts in Moldova was due to two factors: (a) the high degree of soil erosion and small rivers' extreme pollution caused by intensive agriculture and their inadequate monitoring, and (b) the almost complete lack of awareness and experience in using innovative monitoring and control tools in this field. The goal of 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 the use of satellite images to assess time trends in stream bank erosion. It was shown that more than 8.4% of the Baltata River Basin is affected or exposed to erosion; the dominant erosion forms are landslides and gullies, occupying 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 a decrease in 1985-2022, as shown in Figure 4.

3.4 Turkish Pilot Area

In this study, the stream network of the Arhavi River Watershed in Turkey was analyzed for lateral and vertical changes. 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. Topographic maps from the 1960s and images from Google Earth taken in 2011, 2015, and 2017 were used as the foundation layers for digitization. The active channel width, left and right banks, centerlines, and alluvial bars were all defined using ArcGIS 10.8 software (ESRI, California, USA). The Channel Migration Toolbox was used to assess the lateral morphological change. The vertical changes within and along the stream were evaluated using the Cloud Compare software shown in Figure 5 and showcase both deposition and incision during the time period.

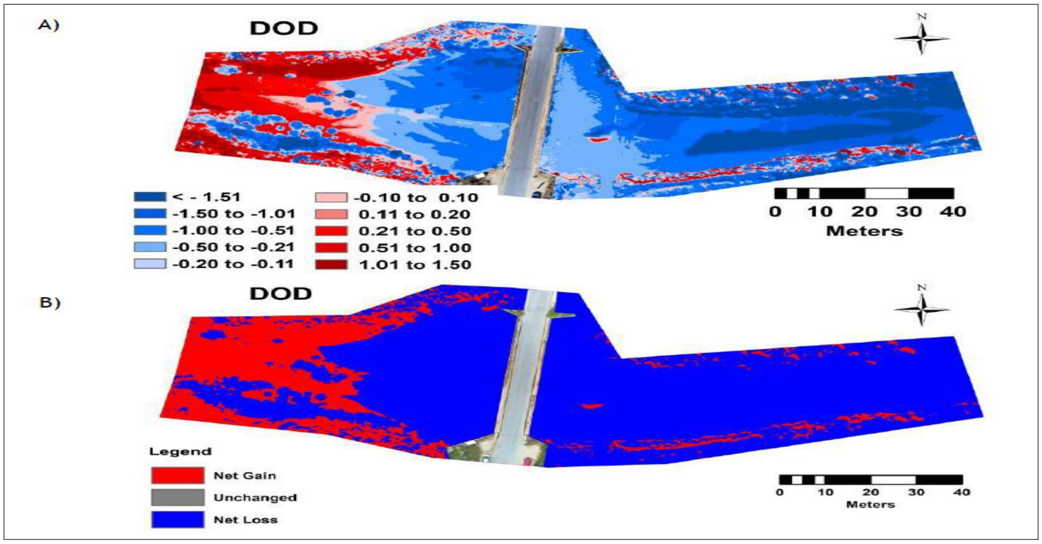

Figure 2: The photos between 14th September 2022 (a) and 28th October 2022 (b) were compared, leading to the DoD. The various elevation categories are represented by the coloured scale (in meters). The three groups were blue, lost material. Grey, unchanged elevation, and red-grained material.

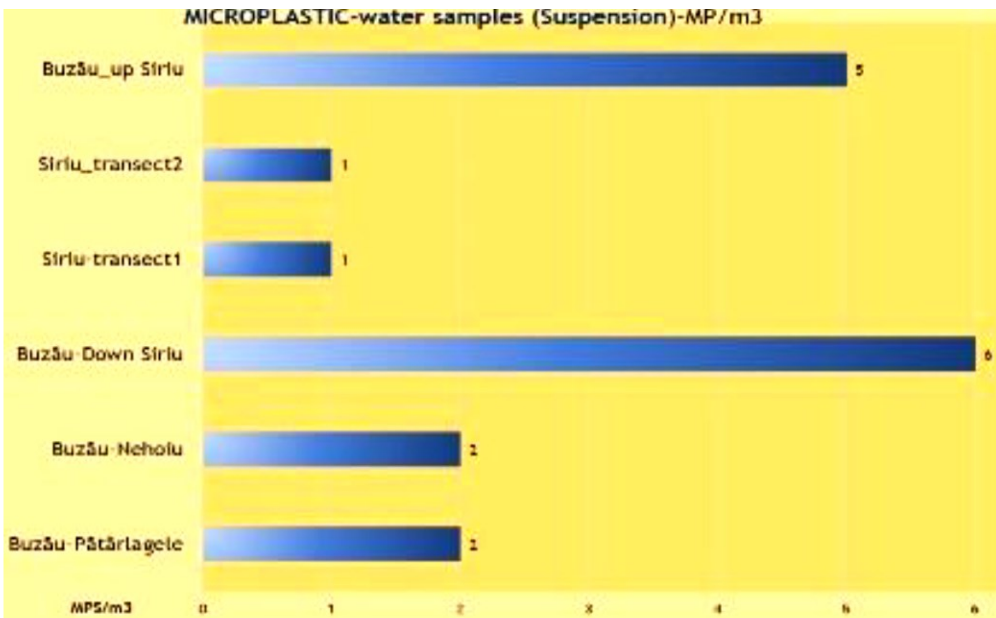

Figure 3: The microplastics in water samples collected in different locations of the Siri reservoir Buzau River Basi

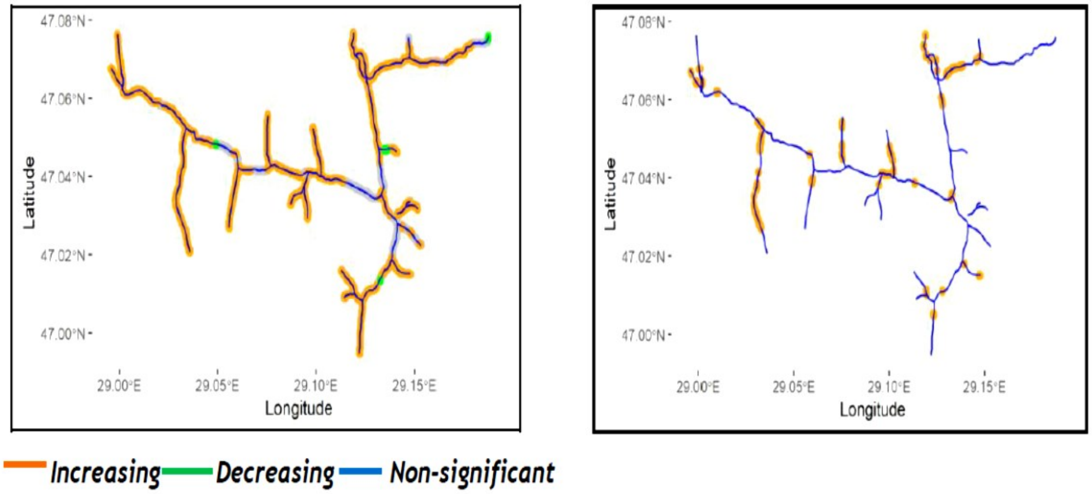

Figure 4: The Time trends in stream bank erosion of Baltata River, 1985-2022 and b) the sectors (in orange) within the Balata River with a strong correlation between stream erosion and time.

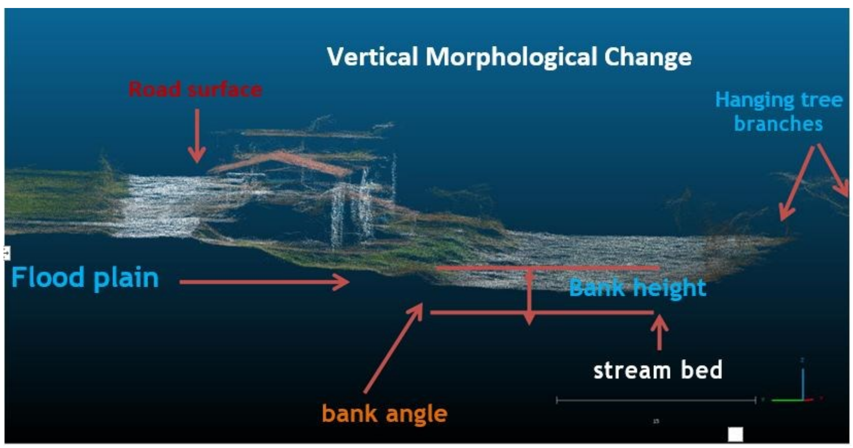

Figure 5: 3D point cloud analysis results of vertical changes of the stream bed and banks in one of the stream networks of Arhavi River Watershed using CloudCompare software.

4.0 CONCLUSION

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

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Data Availability Statement: The associated data is available upon request from the corresponding author.

Declaration Statement of Generative AI: This study did not use any AI software for conducting and completing this study.

REFERENCES

Berov, D., &Klayn, S. (2020). Microplastics and floating litter pollution in Bulgarian Black Sea coastal waters. *Marine Pollution Bulletin, 156*, 111225.https://doi.org/10.1016/j.marpolbul.2020.111225.

Cincinelli, A., Scopetani, C., Chelazzi, D., Martellini, T., Pogojeva, M., &Slobodnik, J. (2021). Microplastics in the Black Sea sediments. *Science of the Total Environment, 760*, 143898.

Feldbacher, E., Paun, M., Reckendorfer, W., Sidoroff, M., Stanica, A., Strimbu, B., & Hein, T. (2016). Twenty years of research on water management issues in the Danube Macro-region—past developments and future directions. *Science of The Total Environment, 572*, 1297-1306.https://doi.org/10.1016/j.scitotenv.2015.12.133

Gkiatas, G. T., Koutalakis, P. D., Kasapidis, I. K., Iakovoglou, V., &Zaimes, G. N. (2022). Monitoring and Quantifying the Fluvio-Geomorphological Changes in a Torrent Channel Using Images from Unmanned Aerial Vehicles. *Hydrology, 9*(10), 184.https://doi.org/10.3390/hydrology9100184

Koutalakis, P., Tzoraki, O., Gkiatas, G., &Zaimes, G. N. (2020). Using UAV to capture and record torrent beds and banks, flood debris, and riparian areas. *Drones, 4*(4), 77.https://doi.org/10.3390/drones4040077

Lechner, A., Keckeis, H., Lumesberger-Loisl, F., Zens, B., Krusch, R., Tritthart, M., &Schludermann, E. (2014). The Danube so colourful: a potpourri of plastic litter outnumbers fish larvae in Europe's second largest river. *Environmental pollution, 188*, 177-181.https://doi.org/10.1016/j.envpol.2014.02.006

Stanev, E. V., & Ricker, M. (2019). The fate of marine litter in semi-enclosed seas: a case study of the Black Sea. *Frontiers in Marine Science, 6*, 660.https://doi.org/10.3389/fmars.2019.00660

Vatandaşlar, C., &Yavuz, M. (2017). Modelling cover management factor of RUSLE using very high-resolution satellite imagery in a semiarid watershed. *Environmental Earth Sciences, 76*, 1-21.https://doi.org/10.1007/s12665-017-6388-0

Zaimes, G. N., Lee, K. H., Tufeckoglu, M., Long, L. A., Schultz, R. C., & Isenhart, T. M. (2011). The effectiveness of riparian conservation practices in reducing sediment in Iowa streams. *Agricultural Research Updates; Hendriks, B., Ed.; Nova Science Publishers, Inc.: Hauppauge, NY, USA*, *2*, 117-166.

Zaimes, G. N., Tufekcioglu, M., & Schultz, R. C. (2019). Riparian land-use impacts on stream bank and gully erosion in agricultural watersheds: What we have learned. *Water, 11*(7), 1343.https://doi.org/10.3390/w11071343