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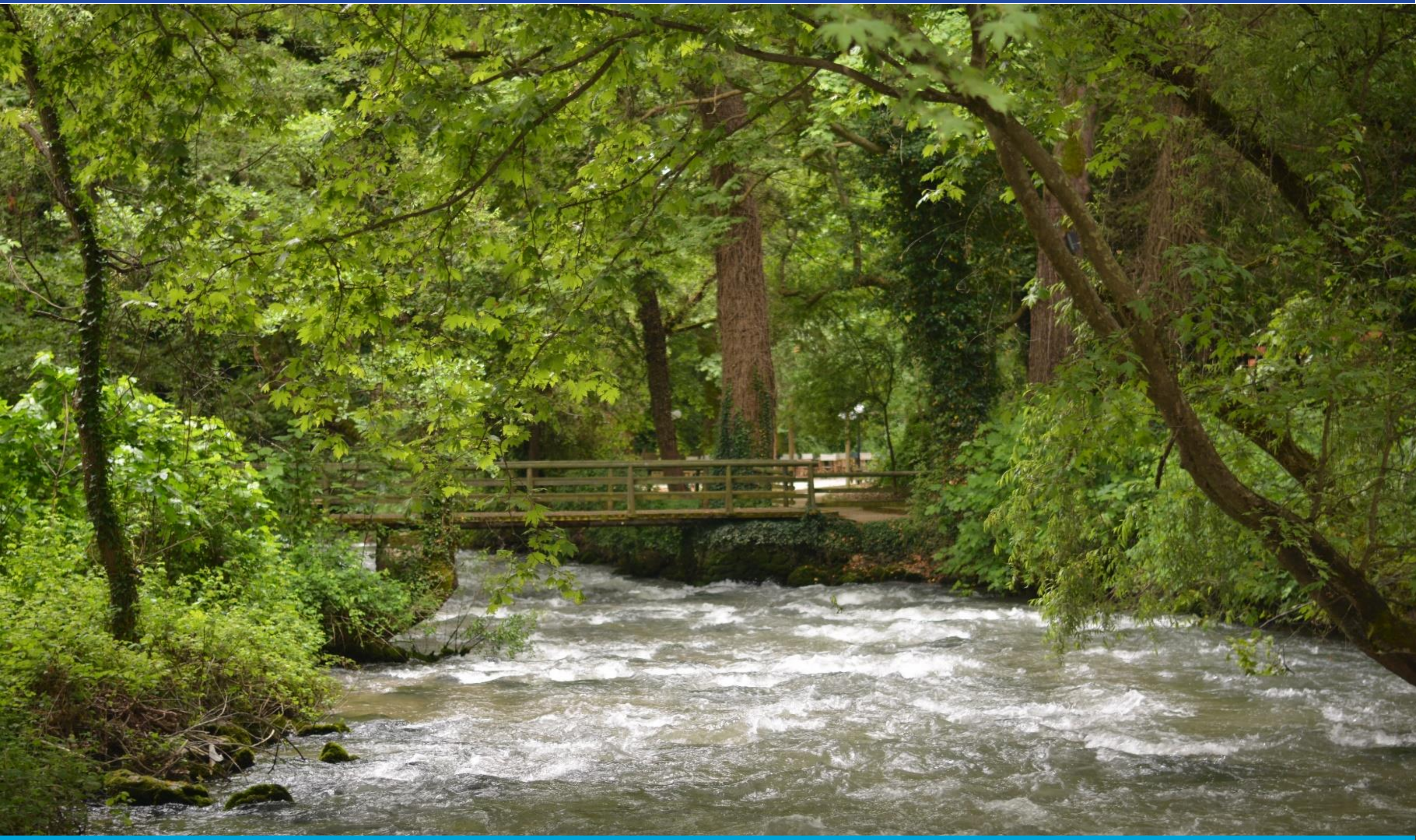

Protect-Streams-4-Sea

REPORT - NON-POINT SOURCE POLLUTANTS

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Common Borders.
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Report on Non-point Source Pollutants

Edited by

Paschalis KOUTALAKIS, Valasia IAKOVOGLOU

Prepared by the teams of:

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1. The Erosion Particles as an Erosion Problem – Examples from Greece

1.1. Introduction on soil erosion

Soil erosion is a natural geomorphologic phenomenon that describes the removal and transportation of the soil particles by forces such as water and wind [90]. Erosional anthropogenic induced factors primary include human activities and interventions to the physical environment (land-use coverage, roads, dams, urban settings, etc.) that typically exacerbated the natural erosional factors and can increase soil erosion exponentially [90].

These anthropogenic activities and interventions have led to soil erosion being one of the most serious environmental problems worldwide. This exacerbated soil erosion can be observed through historical time scales by monitoring changes geomorphologic characteristics [21 and 105]. In Europe, the most susceptible areas to land degradation and desertification appear to be found in the Mediterranean region [21]. The semi-arid Mediterranean region is an area extremely prone to erosion due to the its climate frequent wildfires and the fact the region has been inhabited by humans for thousands of years [104, 114 and 121].

Global warming is also expected to substantially impact soil erosion. It will impact erosion in a number of different processes such as rainfall amounts and intensities, number of days of precipitation, ratio of rain to snow, plant biomass production, plant residue decomposition rates, soil microbial activity, evapotranspiration rates, and shifts in land use necessary to accommodate a new climatic regime [94]. This makes it difficult to predict the exact impacts on soil erosion although it is expected that the erosion and runoff will increase at an even greater rate compared to rainfall intensity that has been forecasted [52].

This clearly indicates the need to understand the future conditions regarding soil erosion in the region. Numerous methodologies were used to assess the threat of erosion and official frameworks for soil monitoring have established for most European countries [91] although there is not yet a European Union common policy to assess the erosion risk except some steps of proposals that are still under discussion [36 and 37].

In Greece, minimal systematic and holistic efforts have been done to reduce this significant environmental problem but an important step was the compilation of a soil erosion risk map [91]. Also, due to technological evolution new soil erosion assessment tools and modeling methodologies have developed [57]. Finally, during the last decades, there was an exponential increase of the publication related to the soil erosion because it is a special risk issue and has close relationship with humans [28].

The first objective was to conduct a representative review of scientific publications that have studied soil erosion in Greece. Afterwards, a systematic analysis of the publications was conducted chronologically, thematically, spatially distributed and by the types of publication (e.g. journal, proceedings etc.). The analysis was important in order to identify the scientific gaps regarding the study of soil erosion risk in Greece.

1.2. Literature Review and Statistical Analysis

Literature Review Method: The electronic database of Scopus was used in order to locate scientific publications that concern soil erosion. The keywords “soil”, “erosion” and “Greece” were inputted in the search engine of Scopus. The initial results of the search were 186 scientific papers. After reviewing, a lot of publications were not added because neither applied on the Greek region nor concerned the soil erosion. The final selection included 130 scientific papers that were journals, proceedings and books. There are probably more publications in other search engines and especially in the Greek language (e.g. proceedings, thesis and books). Also, publications such as hardcopies were not included in this literature review because they are not available in an electronic form.

Literature Analysis: The analysis of the publications was done at four levels. The first level described the type of publication, the second was the chronological display, the third depicted the spatial distribution of the Greek studied areas and the fourth was the thematic. The first level described how any of the publications are in journals, proceedings, books and book chapters. The second level chronicled the publication published from 1980 to February 2015. The third level is the spatial distribution of the studied areas based on the major Greek Geographical Administrative Regions. The last level was the thematic analysis where the publications were grouped into specific subject matters categories and then were grouped into broad subject categories.

1.3. Type of Publications

The vast majority of the publications were in international journals by counting 110 articles. Only four of the publications were found in international proceedings and seven were published in local proceedings, specifically four of them in workshops and three in symposiums. The other nine publications were in books and divided in two types: three of them represented books while six of them were found in book chapters. Figure 1.1. shows the participation percentages of the publications based on the type. In addition, since the literature review was focused on Scopus database, the majority of publication was written in English. Only three of them were written in other language. One book and one journal were written in German, while one journal was in French.

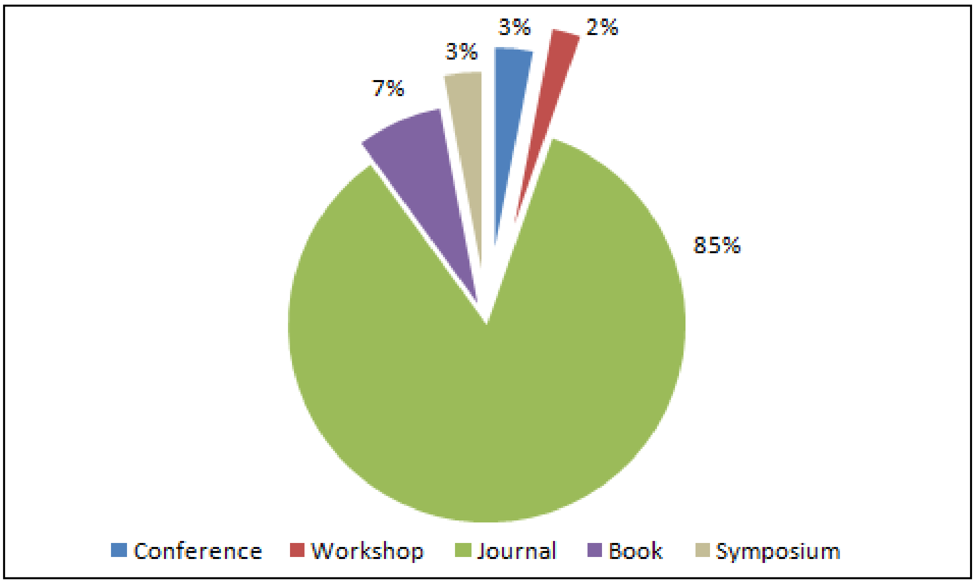

Figure 1.1. The participation of the publication types.

1.4. Chronicle of Publications

There were only nine publications in the eighties (Figure 1.2). In the nineties the publications were tripled compared to the eighties. After the year 2000 the scientific publications continuing to increase their number and were doubled compared to the nineties. The period 2010 to February 2015 had 38 publications, but having regard that this period includes only four years and two months of 2015, it seems that the publications will continue to increase in number. Twelve years had over five publications (1995, 1997, 2000, 2001, 2002, 2005, 2006, 2009, 2010, 2011, 2012 and 2014) and the summary of these years were 83 articles. In addition, the greater number of publications can be found in three years: eleven articles were published in 2011, nine articles in 2010 and ten in 2006. After the year of 2011, it is observed that the publication were fewer (only 18) in regards to previous years. Nevertheless, there trend of the entire period showed a standard linear increase over the years and gave a prediction equation about possible number of publications in future (Figure 1.3). These findings indicate that the interest and awareness on the importance of soil erosion in Greece has increased through decades.

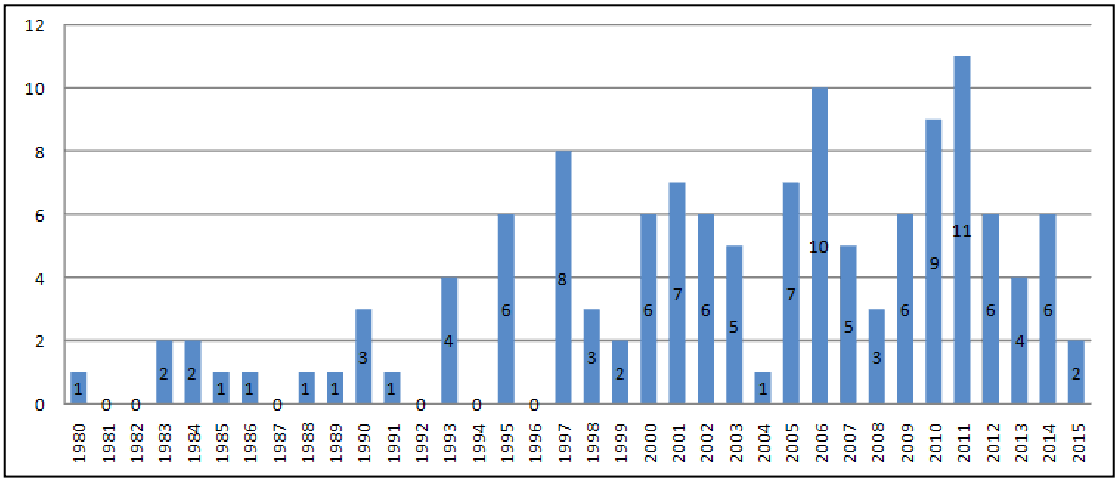

Figure 2.2. The chronologic distribution of publications.

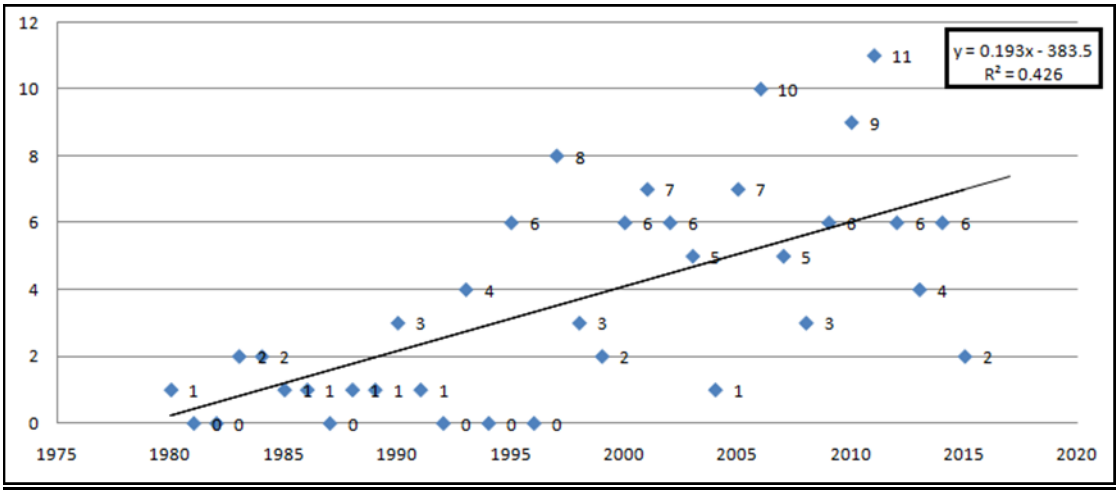

Figure 3.3. The trend of chronologic analysis.

1.5. <u>Spatial Distribution of Publications</u>

After reviewing all the publications, a spatial distribution analysis based on the Greek studied areas was achieved. Greece is divided geographically and administrative in 13 major regions (Figure 1.4). These regions are the following: a) East Macedonia and Thrace, b) Central Macedonia, c) West Macedonia, d) Epirus, e) Thessaly, f) Ionian Islands, g) West Greece, h) Central Greece, i) Attica, j) Peloponnese, k) Crete, l) South Aegean and m) North Aegean. Some of these regions were further sub-divided in order to have a better view. Specifically, East Macedonia and Thrace were separated to two regions, another region was created from the split of Sporades Islands from Thessaly and finally South and North Aegean were divided in three regions: North Aegean, Cyclades Islands and Dodecanese Islands. This process resulted to 16 major regions that were based on the geographically and administrative regions but they also have features from the old traditional geographic divisions of Greece that had geographical, geomorphologic and historical significance.

Figure 4.4. The geographical and administrative regions of Greece.

The analysis (Figure 1.5) resulted that most publications, 18 in number, were reported in Crete Island [2, 18, 20, 38, 42, 49, 51, 53, 56, 60, 69, 70, 72, 79, 80, 89, 100 and 117]. Central Macedonia [3, 8, 41, 68, 78, 86, 93, 97, 102, 108, 111, 115, 118, 119 and 140] and Peloponnese [1, 16, 27, 44, 45, 46, 47, 48, 50, 59, 60, 61, 82, 106 and 107] were represented by 15 articles concerning each region. The region of Thrace was mentioned in 14 publications [8, 41, 58, 63, 64, 66, 67, 92, 98, 116, 122, 128, 138 and 143]. Ten articles were published about the region of Central Greece [25, 29, 30, 71, 110, 123, 124, 125, 131 and 133], while Thessaly had nine [30, 39, 40, 101, 115, 123, 130, 113 and 134]. While Attica is an urban region as it includes the city of Athens, Piraeus and Surroundings; however, eight publications mentioned this region [9, 14, 22, 74, 79, 95, 103 and 131]. Similarly, West Macedonia [10, 33, 34, 41, 65, 77, 126 and 137] had the same number of publications as Attica while it is not characterized as an urban region. Both West Greece [61, 62, 132 and 135] and East Macedonia [35, 41, 84 and 137] were represented by only four articles. Epirus and specifically an area in Igoumenitsa was reported in only one article [41], as well as the Ionian Islands had only one study about Zakynthos Island [54]. North Aegean Islands were represented by eleven publications [4, 5, 6, 11, 75, 76, 86, 87, 88, 99 and 120]; ten of them studied the island of Lesvos. Cyclades Islands were reported in nine articles [17, 19, 26, 32, 43, 55, 83, 109 and 112]. Only two publications were referred to Sporades Islands [24 and 86] and another two mentioned Rhodes [141 and 142] that belongs to Dodecanese Islands. Finally, 13 scientific publications [12, 13, 15, 23, 27, 31, 85, 96, 113, 127, 129, 136 and 139] concerned the entire territory of Greece or they did not specify the exact location.

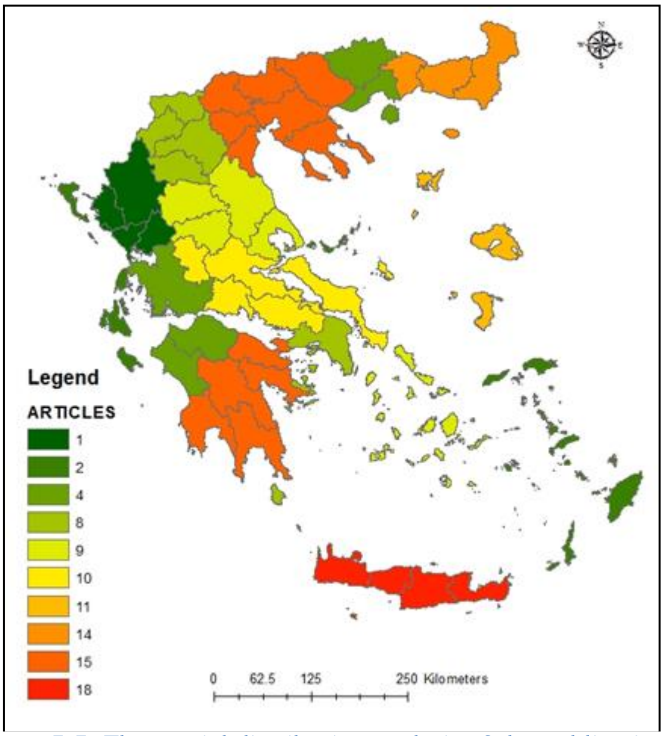

Figure 5.5. The spatial distribution analysis of the publications.

1.6. Thematic Categorization of Publications

After reviewing all the publications, 28 general subject matters were identified. Based on these subject matters, the publications of the review were further grouped into five broad thematic categories. The five thematic categories were the following: a) type of studied land, b) physical phenomena, c) anthropogenic impacts, d) assessment tools and e) management, with each category having three to seven subject matters. Table 1.1 presents the categories, the subject matters, the number of publications in each subject and the percentages in relation to all reviewed scientific publications. It must be noted that most publications covered multiple subject matters and more than one category. In the following sections, the subject matters of each category are discussed in depth.

Table 6.1. The thematic categorization and the participation of the publications.

Category	Subject Matter	Number of publications	Percentage of publications (%)
A) Type of studied land		64	49
	i) Basins/catchments	21	16
	ii) Rivers/streams	5	4
	iii) Lakes/wetlands/ponds	10	8
	iv) Coastal areas	11	8
	v) Natural landscapes	18	14
	vi) Agricultural lands	18	14
	vii) Protected areas	10	8
B) Physical phenomena		92	71
	i) Hydrology	41	32
	ii) Geology	48	37

	iii) Chemistry	16	12
	iv) Wildfires	17	13
	v) Climate	15	12
C) Anthropogenic		75	58
impacts	i) Agricultural activities	31	24
	ii) Forest activities	4	3
	iii) Livestock	12	9
	iv) Urban	19	15
	v) Socio-economic	19	15
	vi) Archaeology	20	15
D) Assessment		93	72
tools	i) Field	37	28
	measurements/observations	24	18
	ii) Laboratory analysis	28	22
	iii) Equations/formulas/indices	16	12
	iv) Remote sensing	32	25
	v) GIS	18	14
	vi) Modeling		
E) Management		77	59
	i) Policies	4	3
	ii) Risk assessment	44	34
	iii) Construction techniques	12	9
	iv) Land management techniques	44	34

1.6.1. The type of land

The category refers to the geographic form and usage of the studied areas. 64 publications (49% of reviewed publications) were counted and divided in seven subjects: i) basins/catchments, ii) rivers/streams, iii) lakes/wetlands/ponds, iv) coastal areas, v) natural landscapes, vi) agricultural landscapes and vii) protected areas. 21 publications subscribed greater basins or smaller catchments [4, 34, 39, 45, 46, 47, 51, 64, 65, 66, 67, 78, 80, 84, 88, 102, 117, 124, 126, 134 and 136], while few articles focused on transported sediment from rivers/streams [35, 63, 101, 130 and 143]. Ten studies represented the bodies of water such as lakes [5, 63, 65, 77, 78, 108, 126 and 137], wetlands [5] and ponds [42]. Eight coastal areas were counted [25, 49, 79, 82, 111, 127, 135 and 138] and three fan deltas [27, 59 and 106] that constitute a mixed environment of both rivers and coasts. Eighteen publications covered natural landscapes that included forests, grasslands, pastures, rangelands, phrygana and terraces [11, 12, 13, 16, 17, 23, 31, 55, 68, 69, 71, 75, 78, 83, 100, 128, 136 and 142]. In addition, eighteen agricultural lands were mentioned; most of them concerned olives, vineyards, cereals and others [2, 5, 11, 38, 53, 56, 70, 72, 74, 75, 78, 89, 116, 122, 123, 124, 129 and 142]. Finally, ten of the studied areas were protected under the Natura 2000 or Ramsar networks [10, 63, 65, 66, 77, 78, 108, 137, 141 and 142].

1.6.2. Physical phenomena

Physical phenomena include the abiotic natural processes that trigger the soil erosion and were divided in five subject's matters: i) hydrology, ii) geology, iii) geochemistry, iv) wildfires and v) climate. There were 92 publications that covered 71% of the total reviewed database. A vast number of publications was related to hydrology as water and soil erosion have a strong relationship [4, 8, 10, 16, 17, 20, 24, 30, 35, 38, 42, 50, 55, 56, 59, 63, 64, 65, 66, 67, 70, 73, 77, 78, 80, 101, 102, 103, 108, 111, 117, 118, 119, 123, 126, 130, 131, 133, 139, 141 and 143]. As soil erosion is a geologic phenomenon, there were many publications referred to geologic matters such as geomorphology [1, 8, 20, 24, 25, 26, 27, 29, 32, 40, 41, 43, 46, 47, 48, 49, 50, 54, 58, 59, 65, 70, 71, 73, 75, 77, 80, 82, 84, 86, 87, 96, 97, 98, 99, 106, 107, 109, 111, 115, 120, 127, 134, 135, 138, 139, 140 and 141], hydrogeology, mineralogy/petrology, landslides, tectonics and geophysics. Many publications discussed the subject of geochemistry that included the physicochemical parameters and the pedogenesis of soils [4, 16, 25, 29, 58, 71, 76, 77, 80, 89, 97, 117, 124, 125, 135 and 139]. A factor that increases the erosion process is the wildfires [15, 16, 17, 18, 29, 31, 35, 38, 56, 93, 103, 119, 131, 132, 137, 141 and 142]. As was mentioned, climate (paleo-climate and climate change) is a sector that affects erosion and it was represented by several publications [9, 10, 18, 20, 44, 51, 56, 79, 88, 101, 106, 107, 111, 115 and 135].

1.6.3. Anthropogenic impacts

This category refers to the negative effects of the human's activities in the environment. 75 publications (58%) were counted and divided in the following subjects: i) agricultural activities, ii) forest activities, iii) livestock, iv) urban, v) socio-economic and vi) archaeology. The majority of publication referred to agricultural activities and their relationship to the soil erosion processes [2, 8, 11, 12, 22, 32, 38, 50, 53, 56, 68, 69, 70, 72, 73, 74, 78, 83, 85, 89, 97, 100, 109, 112, 122, 123, 124, 128, 129, 139 and 141]. Forest activities concerned logging [29, 31 and 140] and skiing [137]. Livestock is an agricultural activity but focused on grazing [6, 11, 13, 18, 22, 60, 68, 69, 77, 100, 117 and 137]. Urban areas included settlements [3, 23, 95, 119, 127, 128 and 138] and engineering constructions such as roads [3, 9, 41, 95, 98, 128 and 141] and dams-reservoirs [42, 66, 108 and 143]. A great number of publications concerned socio-economic impacts [1, 12, 14, 19, 22, 32, 41, 53, 68, 73, 77, 85, 89, 98, 109, 112, 120, 122 and 137] and finally, archaeology included historical settlements and historical human activities that affected the soil erosion [1, 10, 25, 26, 27, 33, 43, 44, 45, 46, 49, 54, 79, 84, 87, 107, 113, 127, 134 and 135].

1.6.4. Assessment tools

This category included 93 publications (72%) that were divided in: i) field measurements/observations, ii) laboratory analysis, iii) equations/formulas/indices, iv) remote sensing, v) GIS and vi) modeling. Field measurements/observations included field plots and experiments [4, 5, 16, 20, 30, 39, 40, 43, 58, 69, 70, 71, 74, 78, 83, 99, 123, 125, 129, 140, 142 and 143], boreholes/wells/cores sampling [10, 44, 49, 79, 80, 85, 88, 108, 112 and 135], geophysical surveys [40 and 59], information by documents [83, 87 and 107] and questionnaires [122]. Laboratory analysis was represented by radio chronology; specifically by dating gamma radiation of isotopes such as Cesium-137 [42, 74, 124 and 125], Carbon-14 [46, 88, 135 and 138] and other isotopes by optical stimulated luminescence dating [45, 46, 47 and 48]. In addition, laboratory analysis includes geotechnical techniques [41, 74, 75, 86, 95, 98 and 125], geophysical analysis [40 and 59] and other physicochemical techniques [4, 5, 10, 25, 58, 76, 80 and 135]. The next subject matter was equations such as Universal Soil Loss Equation (USLE) [4, 19, 54, 64, 67, 93, 100 and 143], Revised Soil Loss Equation (RUSLE) [72, 80, 81, 102, 110 and 116], Gavrilovic [24, 34, 100 and 118] and other algorithmic equations-formulas [4, 30, 51, 64, 66, 67, 102, 108, 120, 123, 129, 130, 133 and 143]. There were many studies that used new technologies in order to manage and depict the erosion risk. These technologies included remote sensing techniques using satellite images [7, 15, 29, 31, 39, 50, 61, 62, 72, 80, 81, 103, 116, 131 and 132], Geographic Information Systems (GIS) [7, 15, 19, 24, 29, 31, 34, 39, 50, 54, 60, 61, 62, 63, 72, 80, 81, 93, 102, 103, 110, 116, 118, 120, 124, 128, 130, 131, 132, 140, 141 and 143] and modeling tools [2, 9, 11, 34, 42, 54, 63, 64, 66, 67, 68, 100, 101, 111, 124, 125, 126 and 140].

1.6.5. Management

The category management was divided in: i) policies, ii) risk assessment, iii) construction techniques and iv) land management techniques. This category had 77 publications covering 59% of the total reviewed articles. The policies took into consideration agricultural policies such as the Common Agricultural Policy [12, 38, 60 and 73]. The risk assessment was represented by studies that produce soil erosion risk maps [7, 15, 19, 22, 24, 29, 31, 34, 39, 40, 50, 60, 61, 65, 72, 80, 81, 92, 93, 100, 102, 103, 111, 116, 120, 130, 131, 132, 141 and 142] and estimations of soil erosion [4, 30, 51, 63, 64, 66, 67, 108, 119, 124 and 125] that could be considered guides for researchers and authorities. Construction techniques included plans that could reduce the erosion by using techniques for slope stabilization [3, 8, 35, 41, 65, 86, 92, 95, 98, 99, 110 and 126]. The last category was land management techniques that referred to conservation and mitigation agricultural plans that preserve and protect the physical environment from soil erosion threats [2, 3, 5, 6, 8, 11, 13, 14, 17, 18, 23, 38, 53, 55, 56, 58, 60, 62, 65, 68, 69, 70, 72, 73, 74, 75, 76, 77, 78, 83, 85, 87, 89, 92, 97, 109, 112, 123, 126, 128, 129, 139, 140 and 142]. It is observed that most studies were related with agricultural land management plans (34%) and studies that produced erosion risk maps (34%).

1.7. Floods – Erosion and Water Pollution in Aggitis Basin

Flood events are frequent, especially in the area of Tenagi-Philippoi, but also in floodplains of the local torrents which are dominant in the area. Figure 1.6 depicts the historic and significant flood events and the area which is vulnerable to floods. In addition, Aggitis discharge is high during spring period because of the high and intense rainfall events and snow melting. Both Aggitis and tributaries cause floods to the adjusted riparian areas and cause serious problems in agriculture and grey infrastructure (Figures 1.7 and 1.8). Furthermore, the high water discharge transports significant amounts of debris material that can be also serious and dangerous because of their dimensions (Figures 1.8 and 1.9). These materials contribute to erosion phenomena and their final deposition can have negative impacts and results to infrastructure and economic damages (Figures 1.10).

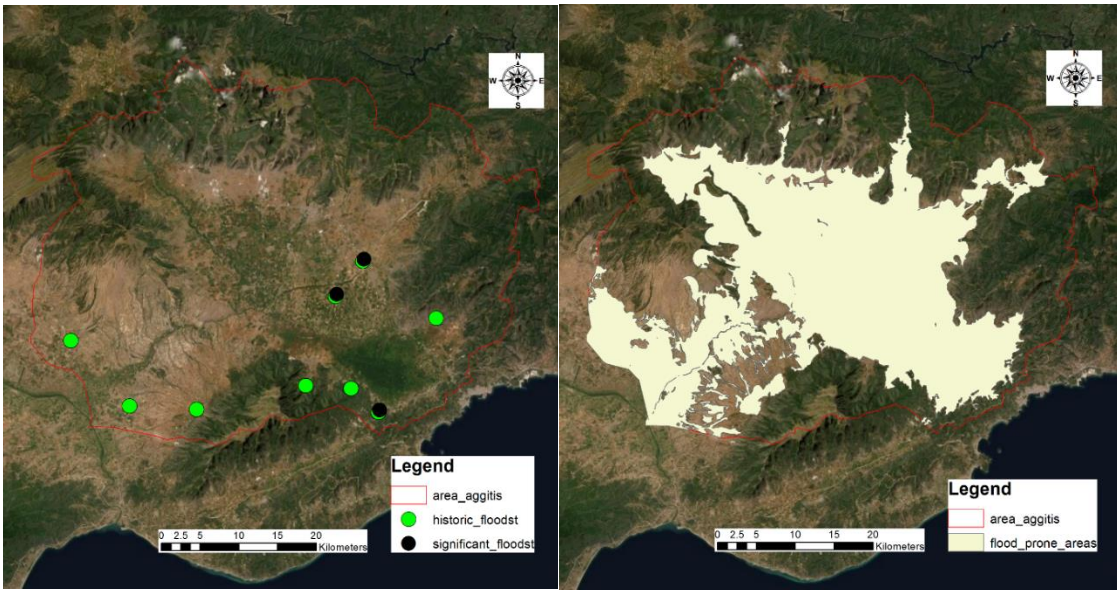

Figure 1.6. The historic and significant flood events and the flood prone map of the pilot area.

Figure 1.7. The Aggitis River flooded after heavy rainfall.

Figure 1.8. A typical sub-urban Greek torrent (ephemeral stream) flooded after heavy rainfall.

Figure 1.9. Floods' debris in Aggitis River after heavy rainfall. .

Figure 1.10. Severe erosion phenomena in Aggitis River after heavy rainfall.

Gravel excavations are riparian intakes of aggregates - transported materials of rivers for the construction of technical works or for other purposes. Gravel extraction, depending on the amount of aggregates obtained, can alter the geometric characteristics of the riverbed and cause hydromorphological alteration of the specific water systems. Such activities are present in many torrents (streams) of the pilot area such as Kallifytos torrent (Figure 1.11).

Figure 1.11. Floods' debris in a typical sub-urban Greek torrent (ephemeral stream) after heavy rainfall

The main sub-sources of non-point pollution originate from the agricultural activities, livestock (pastoral and stable), urban wastewater, charge of water from other sources (Figure 1.12). The area is vulnerable to nitrates, phosphorus and organic material. Stable livestock is divided as: pig farms, poultry farm, sheep farm, cattle farm. In addition, pollution comes from the sanitary landfill and dumps. A typical problem are the illegal garbage dumps of litter, plastics and dangerous pesticide that could end up in surface waters or aquifers (Figure 1.13). There are also mines such as "Bauxite Volaka Mines" which have been abandoned but are still a significant source of pollution for the Kalinas stream which ends at the Xiropotamos stream.

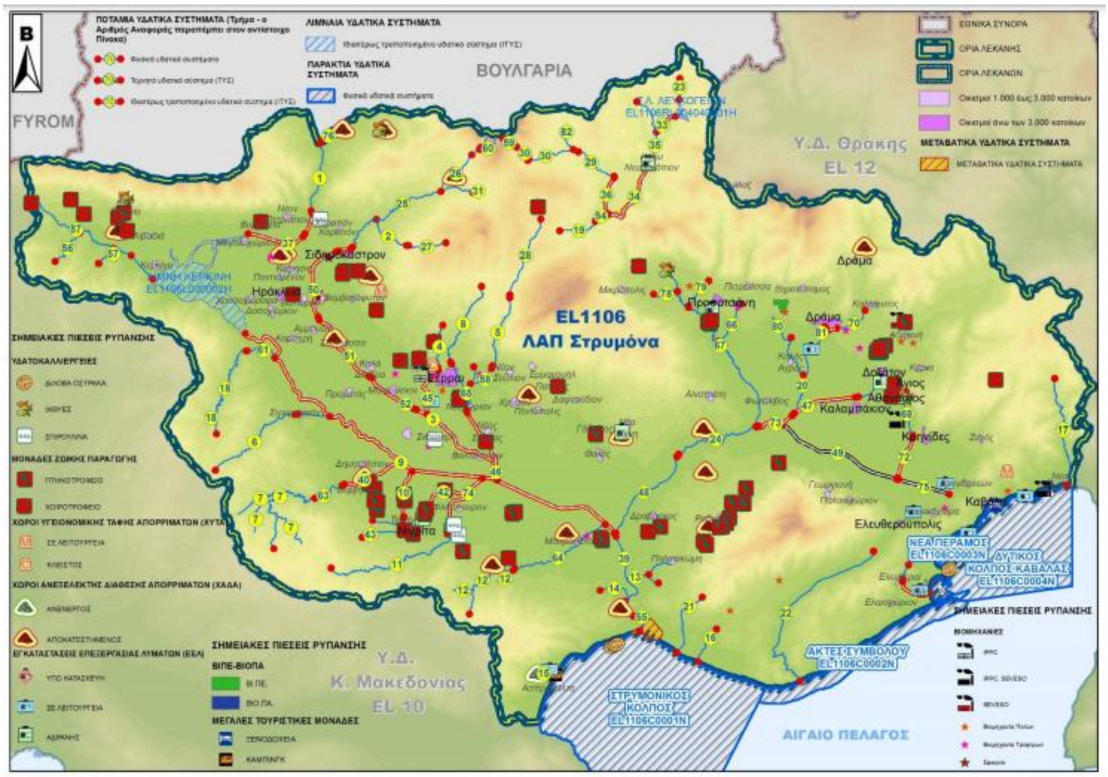

Figure 1.12. The main sources of pollution. Source: Special Secretariat for Water, Hellenic Ministry of Environment and Energy.

Figure 1.13. Typical point source pollutants - illegal garbage dumps of litter, plastics and dangerous pesticides.

References

[1] Astaras, T. (2010) The Gorge of the Angitis River at “Stena Petras” Near the Alistrati Cave. A Magnificent Piece of Natural Architecture in Eastern Macedonia, Greece. In: Evelpidou, N., Figueiredo, T., Mauro, F., Tecim, V., Vassilopoulos, A. (eds) Natural Heritage from East to West. Springer, Berlin, Heidelberg. Acheson, P.E. (1997) Does the 'economic explanation' work? Settlement, agriculture and erosion in the territory of Halieis in the Late Classical-Early Hellenistic period. Journal of Mediterranean Archaeology, 10 (2), pp. 165-190

[2] Allen, HD, Randall, RE, Amable, GS, Devereux, BJ (2006) The impact of changing olive cultivation practices on the ground flora of olive groves in the Messara and Psiloritis regions, Crete, Greece. Land Degradation and Development, 17 (3), pp. 249-273

[3] Anthopoulou, B., Panagopoulos, A., Karyotis, Th. (2006) The impact of land degradation on landscape in Northern Greece. Landslides, 3 (4), pp. 289-294

[4] Arhonditsis, G., Giourga, C., Loumou, A., Koulouri, M. (2002) Quantitative assessment of agricultural runoff and soil erosion using mathematical modeling: Applications in the Mediterranean region. Environmental Management, 30 (3), pp. 434-453

[5] Arhonditsis, G., Giourga, C., Loumou, A. (2000) Ecological patterns and comparative nutrient dynamics of natural and agricultural Mediterranean-type ecosystems. Environmental Management, 26 (5), pp. 527-537

[6] Arianoutsou-Faraggitaki, M. (1985) Desertification by overgrazing in Greece: the case of Lesvos island. Journal of Arid Environments, 9 (3), pp. 237-242

[7] Astaras, T., Lambrinos, N. (1988) Land classification of part of Thrace (East Rhodope) by visual interpretation of MSS images of first and second generation landsat images. GeoJournal, 17 (3), pp. 357-363

[8] Astaras, T. (1984) Drainage basins as process-response systems: an example from central Macedonia, north Greece. Earth Surface Processes & Landforms, 9 (4), pp. 333-341

[9] Athanasopoulou, E., Tombrou, M., Russell, AG, (...), Eleftheriadis, K ., Dandou, A. (2010) Implementation of road and soil dust emission parameterizations in the aerosol model CAMx: Applications over the greater Athens urban area affected by natural sources. Journal of Geophysical Research: Atmospheres, 115 (17), D17301

[10] Aufgebauer, A., Panagiotopoulos, K., Wagner, B., (...), Leng, MJ, Damaschke, M. (2012) Climate and environmental change in the Balkans over the last 17 ka recorded in sediments from Lake Prespa (Albania / FYR of Macedonia / Greece). Quaternary International, 274, pp. 122-135

[11] Bakker, MM, Govers, G., Kosmas, C., (...), Oost, KV, Rounsevell, M. (2005) Soil erosion as a driver of land-use change. Agriculture, Ecosystems and Environment, 105 (3), pp. 467-481

[12] Barbayiannis, N., Panayotopoulos, K., Psaltopoulos, D., Skuras, D. (2011) The influence of policy on soil conservation: A case study from Greece. Land Degradation and Development, 22 (1), pp. 47-57

[13] Barbero, M., Quezel, P. (1983) La vegetation de la Grece et l'action de l'homme. | [(The vegetation of Greece and human action).] Mediterranee, 48 (2), pp. 65-71

[14] Bevan, A., Conolly, J. (2011) Terraced fields and Mediterranean landscape structure: An analytical case study from Antikythera, Greece. Ecological Modelling, 222 (7), pp. 1303-1314

[15] Bindel, M., Gähler, M., Schneiderhan, T., Schmullius, C. (2009) A semi-automated, object-based algorithm for burned area mapping in the Mediterranean Region using multisensoral Remote Sensing data. Proceedings, 33rd International Symposium on

Remote Sensing of Environment, ISRSE 2009 CONFERENCE pp. 515-518
[16] Blake, WH, Theocharopoulos, SP, Skoulikidis, N., (...), Hartley, R., Amaxidis, Y. (2010) Wildfire impacts on hillslope sediment and phosphorus yields. Journal of Soils and Sediments, 10 (4), pp. 671-682
[17] Bohling, N., Gerold, G. (1995) Post-fire regeneration patterns and variations of soil properties in Mediterranean phrygana-areas of Naxos / Greece. Geookodynamik, 16 (3-4), pp. 333-345
[18] Boix, C., Calvo, A., Imeson, AC, (...), Soto, S., Tiemessen, IR (1995) Properties and erosional response of soils in a degraded ecosystem in Crete (Greece). Environmental Monitoring & Assessment, 37 (1-3), pp. 79-92
[19] Centeri, C., Kristóf, D., Evelpidou, N., (...), Giotitsas, I., Varvarigos, G. (2011) Soil erosion risk and sediment transport within paros Island, Greece. Soil Erosion: Causes, Processes and Effects, Book Chapter Nova Science Publishers pp. 219-234
[20] Cerdà, A. (1998) Relationships between climate and soil hydrological and erosional characteristics along climatic gradients in Mediterranean limestone areas. Geomorphology, 25 (1-2), pp. 123-134
[21] Cerdan, O., Desprats, J.-F., Fouché, J., (...), Raclot, D., Mouillot, F. (2011) Impact of global changes on soil vulnerability in the Mediterranean Basin. ASABE - International Symposium on Erosion and Landscape Evolution, pp. 495-503
[22] Christodoulou, M., Nakos, G. (1990) An approach to comprehensive land use planning. Journal of Environmental Management, 31 (1), pp. 39-46
[23] Christopoulou, O., Polyzos, S., Minetos, D. (2007) Peri-urban and urban forests in Greece: Obstacle or advantage to urban development? Management of Environmental Quality, 18 (4), pp. 382-395
[24] Dalaris, M., Psilovikos, A., Sapountzis, M., Mourtzis, P., Mourtzios, P. (2013) Water erosion assessment in skiathos island using the gavrilovic method. Fresenius Environmental Bulletin, 22 (10), pp. 2943-2952
[25] Davidson, DA, Wilson, CA, Lemos, IS, Theocharopoulos, SP (2010) Tell formation processes as indicated from geoarchaeological and geochemical investigations at Xeropolis, Euboea, Greece. Journal of Archaeological Science, 37 (7), pp. 1564-1571
[26] Davidson A.D. (1980) Erosion in Greece during the first and second millennia BC. R.A. Cuilingford, R.A. Davidson, J. Levin (Eds.), Timescales in Geomorphology, John Wiley and Sons, New York (1980), pp. 143-158
[27] Davidson A.D. (1991) Soil erosion in the Mediterranean Basin. Geography, 76 (1) pp71-73
[28] Dekker, LW, Oostindie, K., Ritsema, CJ (2005) Exponential increase of publications related to soil water repellency. Australian Journal of Soil Research, 43 (3), pp. 403-441
[29] De Vliegher, B.M. (1990) Environmental degradation mapping in Euboia (central Greece) using multisource satellite data Proceedings of the tenth EARSeL symposium: new European systems, sensors and applications, Toulouse, 1990 pp. 297-305
[30] Dimoyiannis, D., Valmis, S., Danalatos, NG (2006) Interrill erosion on cultivated Greek soils: Modelling sediment delivery. Earth Surface Processes and Landforms, 31 (8), pp. 940-949
[31] Drosos, VC, Giannoulas, VJ, Daoutis, C. (2014) Forest construction infrastructures for the prevision, suppression, and protection before and after forest fires. Proceedings of SPIE - The International Society for Optical Engineering
[32] Economou, A., Skouteri, A., Michopoulos, P. (2007) Soils and land use of Santorini, Greece. Soils of Volcanic Regions in Europe, Book chapter pp. 623-628 Springer-

Verlag Berlin Heidelberg
[33] Efstratiou, N., Biagi, P., Elefanti, P., Karkanas, P., Ntinou, M. (2006) Prehistoric exploitation of Grevena highland zones: Hunters and herders along the Pindus chain of western Macedonia (Greece). World Archaeology, 38 (3), pp. 415-435
[34] Emmanouloudis, DA, Christou, OP, Filippidis, EI (2003) Quantitative estimation of degradation in the Aliakmon River basin using GIS. IAHS-AISH Publication, (279), pp. 234-240
[35] Emmanouloudis, D., Takos, I., Spanos, I. (2002) Evolution of the erosive process after a watershed fire: An example: Prinos torrent, Thassos island, Greece. Management Information Systems, CONFERENCE pp. 265-276
[36] European Commission (EC) 2002 Towards a strategy for soil protection. pp. 179
[37] European Commission (EC) 2006 Thematic strategy for soil protection. pp. 231
[38] Fleskens, L (2008) A typology of sloping and mountainous olive plantation systems to address natural resources management. Annals of Applied Biology, 153 (3), pp. 283-297
[39] Floras, S.A., Sgouras, I.D. (1999) Use of geoinformation techniques in identifying and mapping areas of erosion in a hilly landscape of central Greece. International Journal of Applied Earth Observation and Geoinformation, 1 (1), pp. 68-77
[40] Floras, S.A., Sgouras, I. (1993) Evaluation of erosion processes on an area of the Karla Basin in Larissa, Greece. Farm land erosion in temperate plains environment and hills. Proc. symposium, Saint-Cloud, Paris, 1992 pp. 415-427
[41] Flum, D., Salzmann, H., Züger, M. (2005) Replacement of failed shotcrete facing by a flexible slope stabilisation system. Polish Geological Institute Special Papers, 20, pp. 40-45
[42] Foteinis, S., Mpizoura, K., Panagopoulos, G., (...), Kallithrakas-Kontos, N ., Manutsoglu, E. (2014) A novel use of the caesium-137 technique to estimate human interference and historical water level in a Mediterranean Temporary Pond. Journal of Environmental Radioactivity, 127, pp. 75-81
[43] French, C.A.I., Whitelaw, T.M. (1999) Soil Erosion, Agricultural Terracing and Site Formation Processes at Markiani, Amorgos, Greece: The Micromorphological Perspective. Geoarchaeology - An International Journal, 14 (2), pp. 151-189
[44] Fuchs, M (2007) An assessment of human versus climatic impacts on Holocene soil erosion in NE Peloponnese, Greece. Quaternary Research, 67 (3), pp. 349-356
[45] Fuchs, M. (2006) Mensch und Umwelt in der Antike Südgriechenlands: Ergebnisse geoarchäologischer Forschung im Becken von Phlious, Nordost-Peloponnes | [Man and environment in antique Greece: Geoarchaeological investigations in the basin of Phlious, Northeast-Peloponnese]. Geographische Rundschau, 58 (4), pp. 4-11
[46] Fuchs, M., Wagner, G.A. (2005) The chronostratigraphy and geoarchaeological significance of an alluvial geoarchive: Comparative OSl and AMS 14C dating from Greece. Archaeometry, 47 (4), pp. 849-860
[47] Fuchs, M., Lang, A., Wagner, GA (2004) The history of Holocene soil erosion in the Phlious Basin, NE Peloponnese, Greece, based on optical dating. Holocene, 14 (3), pp. 334-345
[48] Fuchs, M., Wagner, G.A (2003) Recognition of insufficient bleaching by small aliquots of quartz for reconstructing soil erosion in Greece. Quaternary Science Reviews, 22 (10-13), pp. 1161-1167
[49] Fytrolakis, N., Peterek, A., Schröder, B. (2005) Initial geoarchaeologic investigations on the Holocene coastal configuration near Phaistos / Agia Triada (Messara plain central Crete, Greece). Zeitschrift fur Geomorphologie, Supplementband, 137, pp. 111-123
[50] Gatsis I., Pavlopoulos A (2001) Geomorphological observations and related natural

hazards using merged remotely sensed data: A case study in the corinthos area (NE Peloponnese, S. Greece). Geografiska Annaler, Series A: Physical Geography, 83 (4), pp. 217-228
[51] Giakoumakis, SG, Tsakiris, GP (1997) Meteorological Drought Effect on Sediment Yield. Water Resources Management, 11 (5), pp. 365-376
[52] Giupponi C, and M Shechter (eds.) (2003) Climate Change in the Mediterranean: Socio-Economic Perspectives of Impacts, Vulnerability and Adaptation. Edward Elgar Publications, Glos, UK.
[53] Gomez, JA, Amato, M., Celano, G., Koubouris, GC (2008) Organic olive orchards on sloping land: More than a specialty niche production system? Journal of Environmental Management, 89 (2), pp. 99-109
[54] Gouma, M., van Wijngaarden, GJ, Soetens, S. (2011) Assessing the effects of geomorphological processes on archaeological densities: A GIS case study on Zakynthos Island, Greece. Journal of Archaeological Science, 38 (10), pp. 2714-2725
[55] Grabner, S., Heiselmayer, P. (2000) Vegetation dynamics of phrygana in erosion rills on Mykonos (Greece). Acta Botanica Croatica, 59 (1), pp. 111-134
[56] Grove, A.T., Rackham, O. (1993) Threatened landscapes in the Mediterranean: examples from Crete. Landscape and Urban Planning, 24 (1-4), pp. 279-292
[57] Hagyó, A., Tóth, T., Bloem, E., Van Der Zee, SEATM, Horváth, E. (2008) Soil-plant interrelations: The significance of soil degradation and the the risk assessment methodology for salinization. Cereal Research Communications
[58] Haidouti, C., Karyotis, T., Massas, I., Haroulis, A. (2001) Red soils of Thrace (Greece): Properties, development, and productivity. Communications in Soil Science and Plant Analysis, 32 (5-6), pp. 617-632
[59] Hasiotis, T., Charalampakis, M., Stefatos, A., Papatheodorou, G., Ferentinos, G. (2006) Fan delta development and processes offshore a seasonal river in a seismically active region, NW Gulf of Corinth. Geo-Marine Letters, 26 (4), pp. 199-211
[60] Hill, J., Hostert, P., Tsiourlis, G., (...), Udelhoven, T., Diemer, C. (1998) Monitoring 20 years of increased grazing impact on the Greek island of Crete with earth observation satellites. Journal of Arid Environments, 39 (2), pp. 165-178
[61] Hill, J., Megier, J., Mehl, W. (1995) Land degradation, soil erosion and desertification monitoring in Mediterranean ecosystems. Remote Sensing Reviews, 12 (1-2), pp. 107-130
[62] Hill, J. (1993) Monitoring land degradation and soil erosion in Mediterranean environments. ITC Journal, 1993-4, pp. 323-331
[63] Hrissanthou, V., Delimani, P., Xeidakis, G. (2010) Estimate of sediment inflow into Vistonis Lake, Greece. International Journal of Sediment Research, 25 (2), pp. 161-174
[64] Hrissanthou, V (2005) Estimate of sediment yield in a basin without sediment data. Catena, 64 (2-3), pp. 333-347
[65] Hrissanthou, V., Mylopoulos, N., Tolikas, D., Mylopoulos, Y. (2003) Simulation modeling of runoff, groundwater flow and sediment transport into Kastoria Lake, Greece. Water Resources Management, 17 (3), pp. 223-242
[66] Hrissanthou, V. (2002) Comparative application of two erosion models to a basin. Hydrological Sciences Journal, 47 (2), pp. 279-292
[67] Hrissanthou, V. (1998) Comparison between two mathematical models for the computation of sediment yield from a basin. AHS-AISH Publication, 249, pp. 137-142
[68] Ibañez, J., Valderrama, JM, Papanastasis, V., Evangelou, C., Puigdefabregas, J. (2014) A multidisciplinary model for assessing degradation in Mediterranean rangelands.

Land Degradation and Development, 25 (5), pp. 468-482
[69] Kairis, O., Karavitis, C., Salvati, L., Kounalaki, A., Kosmas, K. (2015) Exploring the Impact of Overgrazing on Soil Erosion and Land Degradation in a Dry Mediterranean Agro-Forest Landscape (Crete, Greece). Arid Land Research and Management, 29 (3), pp. 360-374.
[70] Kairis, O., Karavitis, C., Kounalaki, A., Salvati, L., Kosmas, C. (2013) The effect of land management practices on soil erosion and land desertification in an olive grove. Soil Use and Management, 29 (4), pp. 597-606
[71] Kalatha, S., Economou-Eliopoulos, M. (2015) Framboidal pyrite and bacterio-morphic goethite at transitional zones between Fe-Ni-laterites and limestones: Evidence from Lokris, Greece. Ore Geology Reviews, 65 (P1), pp. 413-425
[72] Karydas, CG, Sekuloska, T., Silleos, GN (2009) Quantification and site-specification of the support practice factor when mapping soil erosion risk associated with olive plantations in the Mediterranean island of Crete. Environmental Monitoring and Assessment, 149 (1-4), pp. 19-28
[73] Kosmas C., Danalatos N., Kosma D. Kosmopoulou P. (2006) Greece. Soil Erosion in Europe
[74] Kosmas, C., Gerontidis, St., Marathianou, M., (...), Quine, T., Vanoost, K. (2001) The effects of tillage displaced soil on soil properties and wheat biomass. Soil and Tillage Research, 58 (1-2), pp. 31-44
[75] Kosmas, C., Danalatos, NG, Gerontidis, S. (2000) The effect of land parameters on vegetation performance and degree of erosion under Mediterranean conditions. Catena, 40 (1), pp. 3-17
[76] Kosmas, C., Gerontidis, S., Marathianou, M. (2000) The effect of land use change on soils and vegetation over various lithological formations on Lesvos (Greece). Catena, 40 (1), pp. 51-68
[77] Kosmas, CS, Danalatos, NG, Moustakas, NK (1997) The soils. Hydrobiologia, 351, pp. 21-33
[78] Kosmas, C., Danalatos, N., Cammeraat, LH, (...), Usai, D., Vacca, A. (1997) The effect of land use on runoff and soil erosion rates under Mediterranean conditions. Catena, 29 (1), pp. 45-59
[79] Kouli K. (2012) Vegetation development and human activities in Attiki (SE Greece) during the last 5,000 years. Vegetation History and Archaeobotany, 21 (4-5), pp. 267-278
[80] Kouli, M., Kalisperi, D., Soupios, P., Vallianatos, F. (2011) Modeling soil erosion processes in watersheds and the relation between soil loss with geomorphic and chemical parameters. Watersheds: Management, Restoration and Environmental Impact, Book Chapter Nova Science Publishers
[81] Kouli, M., Soupios, P., Vallianatos, F. (2009) Soil erosion prediction using the Revised Universal Soil Loss Equation (RUSLE) in a GIS framework, Chania, Northwestern Crete, Greece. Environmental Geology, 57 (3), pp. 483-497
[82] Leeder, MR, Collier, RELl., Abdul Aziz, LH, (...), Papatheodorou, G., Lyberis, E. (2002) Tectono-sedimentary processes along an active marine / lacustrine half-graben margin: Alkyonides gulf, E. Gulf of Corinth, Greece. Basin Research, 14 (1), pp. 25-41
[83] Lehmann, R. (1993) Terrace degradation and soil erosion on Naxos Island, Greece. S. Wicherek (Ed.), Farm Land Erosion, In Temperate Plains Environment and Hills, Elsevier Science Publishers (1993), pp. 429-445
[84] Lespez, L. (2003) Geomorphic responses to long-term land use changes in Eastern Macedonia (Greece). Catena, 51 (3-4), pp. 181-208
[85] Lithourgidis, AS, Damalas, CA, Eleftherohorinos, IG (2009) Conservation tillage: A

promising perspective for sustainable agriculture in Greece. Journal of Sustainable Agriculture, 33 (1), pp. 85-95
[86] Lykousis, V., Chronis, G (1989) Mass movements, geotechnical properties, and slope stability in the outer shelf-upper slope, northwestern Aegean Sea. Marine Geotechnology, 8 (3), pp. 231-247
[87] Marathianou, M., Kosmas, C., Gerontidis, St., Detsis, V. (2000) Land-use evolution and degradation in Lesvos (Greece): A historical approach. Land Degradation and Development, 11 (1), pp. 63-73
[88] Margari, V., Gibbard, PL, Bryant, CL, Tzedakis, PC (2009) Character of vegetational and environmental changes in southern Europe during the last glacial period; evidence from Lesvos Island, Greece. Quaternary Science Reviews, 28 (13-14), pp. 1317-1339
[89] Metzidakis, I., Martinez-Vilela, A., Castro Nieto, G., Basso, B. (2008) Intensive olive orchards on sloping land: Good water and pest management are essential. Journal of Environmental Management, 89 (2), pp. 120-128
[90] Montgomery D.R., 2007. Soil erosion and agriculture sustainability. Proceeding of the National Academy of Sciences of the United States of America. Vol 104(33), pp 13268-13272.
[91] Morvan, X., Saby, NPA, Arrouays, D., (...), Stephens, M., Kibblewhite, MG. (2008) Soil monitoring in Europe: A review of existing systems and requirements for harmonization. Science of the Total Environment, 391 (1), pp. 1-12
[92] Myronidis, D., Ioannou, K., Sapountzis, M., Fotakis, D. (2010) Development of a sustainable plan to combat erosion for an island of the Mediterranean region. Fresenius Environmental Bulletin, 19 (8 B), pp. 1694-1702
[93] Myronidis, DI, Emmanouloudis, DA, Mitsopoulos, IA, Riggos, EE (2010) Soil Erosion Potential after Fire and Rehabilitation Treatments in Greece. Environmental Modeling and Assessment, 15 (4), pp. 239-250
[94] Nearing MA, Pruski F.F., and O'Neal M.R. (2004) Expected climate change impacts on soil erosion rates: A review. Journal of Soil and Water Conservation 59(1), pp. 43-50
[95] Nektarios, PA, Ntoulas, N., Zacharopoulou, A., Chronopoulos, I. (2010) Athens concert hall roof garden construction. Acta Horticulturae, 881, pp. 683-688
[96] Neboit-Guilhot, R. (1990) Les contraintes physiques et la fragilite du milieu mediterraneen | [Physical constraints and fragility of the Mediterranean area]. Annales de Geographie, 551, pp. 1-20
[97] Noulas, C., Karyotis, T., Charoulis, A., Massas, I. (2009) Red mediterranean soils: Nature, properties, and management of rhodoxeralfs in northern Greece. Communications in Soil Science and Plant Analysis, 40 (1-6), pp. 633-648
[98] Oikonomou, N., Eskioglou, P. (2006) Marble treatment waste for slope stabilization. Fresenius Environmental Bulletin, 15 (3), pp. 239-241
[99] Oostwoud Wijdenes, DJ, Poesen, J., Vandekerckhove, L., Kosmas, C. (2001) Measurements at one-year interval of rock-fragment fluxes by sheep trampling on degraded rocky slopes in the Mediterranean. Zeitschrift fur Geomorphologie, 45 (4), pp. 477-500
[100] Panagos, P., Christos, K., Cristiano, B., Ioannis, G. (2014) Seasonal monitoring of soil erosion at regional scale: An application of the G2 model in Crete focusing on agricultural land uses. International Journal of Applied Earth Observation and Geoinformation, 27 (PARTB), pp. 147-155
[101] Panagoulia, D.a, Dimou, G.b (1997) Sensitivity of flood events to global climate change. Journal of Hydrology, Volume 191, Issue 1-4, 1997, Pages 208-222
[102] Papazoglou, DPE, Rizopoulou, AA (2011) Estimation of erosion rate on anthemountas

basin. CEUR Workshop Proceedings Conference 1152, pp. 813-825
[103] Pavlopoulos, A., Katsaros, K., Stamatis, G., Parcharidis, I. (1997) Hydrologic properties and resistance maps of runoff in Pendelikon region, Attica, Greece, before and after the wildfire hazards, by using GIS and RS techniques (Article). Engineering geology and the environment. Proc. symposium, Athens, 1997 vol.1 pp. 321-325
[104] Pearce, F. (1996) Deserts on our doorstep. New Scientist, 151 (2037), pp. 12-13
[105] Podmanicky, L., Balázs, K., Belényesi, M., (...), Kristóf, D., Kohlheb, N. (2011) Modelling soil quality changes in Europe. An impact assessment of land use change on soil quality in Europe. Ecological Indicators, 11 (1), pp. 4-15
[106] Pope, R.J.J., Wilkinson, K.N. (2005) Reconciling the roles of climate and tectonics in Late Quaternary fan development on the Spartan piedmont, Greece. Geological Society Special Publication, 251, pp. 133-152
[107] Pope, K.O., van Andel, T.H. (1984) Late quaternary alluviation and soil formation in the southern Argolid: its history, causes and archaeological implications. Journal of Archaeological Science, 11 (4), pp. 281-306
[108] Psilovikos, A., Margoni, S. (2010) An empirical model of sediment deposition processes in Lake Kerkini, Central Macedonia Greece. Environmental Monitoring and Assessment, 164 (1-4), pp. 573-592
[109] Riedl, H., Kern, W. (1995) Beitrage zur Landeskunde von Griechenland V | [Contributions to the geography of Greece. V pp 345
[110] Rozos, D., Skilodimou, HD, Loupasakis, C., Bathrellos, GD (2013) Application of the revised universal soil loss equation model on landslide prevention. An example from N. Euboea (Evia) Island, Greece. Environmental Earth Sciences, 70 (7), pp. 3255-3266
Samaras, A.G., Koutitas, C.G. (2014) Modeling the impact of climate change on sediment transport and morphology in coupled watershed-coast systems: A case study using an integrated approach. International Journal of Sediment Research, 29 (3), pp. 304-315
Schrader, K. (1995) Die griechische Insel Naxos - eine bedrohte Landschaft | [The Greek island of Naxos - a threatened landscape]. Erde, 126 (1), pp. 73-86
Seymour, J., Girardet, H. (1986) Far from paradise: the story of man's impact on the environment. London (1986), p. 216
[111] Shakesby RA. 2011. Post-wildfire soil erosion in the Mediterranean: Review and future research directions. Earth-Science Reviews 105, pp. 71-100.
[112] Smith, GW, Nance, RD, Genes, AN (1997) Quaternary glacial history of Mount Olympus, Greece. Bulletin of the Geological Society of America, 109 (7), pp. 809-824
[113] Sotiropoulou, A.-M., Alexandridis, T., Bilas, G., (...), Silleos, N., Misopolinos, N. (2011) A user friendly GIS model for the estimation of erosion risk in agricultural land using the USLE. CEUR Workshop Proceedings, Conference 1152, pp. 795-801
[114] Stamati, FE, Nikolaidis, NP, Venieri, D., Psillakis, E., Kalogerakis, N. (2011) Dissolved organic nitrogen as an indicator of livestock impacts on soil biochemical quality. Applied Geochemistry, 26 (SUPPL.), pp. S340-S343
[115] Stefanidis, S. (2011) Estimation of the mean annual sediment discharge in fire affected watersheds. Silva Balcanica, 12 (1), pp. 91-96
[116] Stefanidis, P., Sapountzis, M., Stathis, D. (2002) Sheet erosion after fire at the urban forest of Thessaloniki (Northern Greece). Silva Balcanica, (2), pp. 65-77
[117] Symeonakis, E., Karathanasis, N., Koukoulas, S., Panagopoulos, G. (2014) Monitoring sensitivity to land degradation and desertification with the environmentally sensitive area index: The case of lesvos island. Land Degradation and Development, Article in Press.
[118] Tal, A. (2010) Desertification (Book Chapter) Turning Points of Environmental History

pp. 146-161
[119] Tampakis, S., Karanikola, P., Koutroumanidis, T., Tsitouridou, Ch. (2010) Protecting the productivity of cultivated land. The viewpoints of farmers in Northern Evros. Journal of Environmental Protection and Ecology, 11 (2), pp. 601-613
[120] Terzoudi, Chr.B., Gemtos, TA, Danalatos, NG, Argyrokastritis, I. (2007) Applicability of an empirical runoff estimation method in central Greece. Soil and Tillage Research, 92 (1-2), pp. 198-212
[121] Theocharopoulos, SP, Florou, H., Walling, DE, (...), Tountas, P., Nikolaou, T. (2003) Soil erosion and deposition rates in a cultivated catchment area in central Greece, estimated using the 137Cs technique. Soil and Tillage Research, 69 (1-2), pp. 153-162
[122] Theocharopoulos, SP, Florou, H., Kritidis, P., (...), Kouloumbis, P., Nikolaou, T. (2000) Use of 137Cs isotopic technique in soil erosion studies in Central Greece. Acta Geologica Hispanica, 35 (3-4), pp. 301-310
[123] Tolikas, D., Hrissanthou, V., Mylopoulos, Y., Koudoumakis, P. (2001) Sediment control in the basin of Kastoria Lake. Progress in Water Resources, pp. 385-393
[124] Tourloukis, V.a, Karkanas, P. (2012) Geoarchaeology in Greece: A review. Journal of the Virtual Explorer, 42, pp 4.
[125] Triantakonstantis, DP, Kalivas, DP, Kollias, VJ (2013) Autologistic regression and multicriteria evaluation models for the prediction of forest expansion. New Forests, 44 (2), pp. 163-181
[126] Tsara, M., Gerontidis, S., Marathianou, M., Kosmas, C. (2001) The long-term effect of tillage on soil displacement of hilly areas used for growing wheat in Greece. Soil Use and Management, 17 (2), pp. 113-120
[127] Tsimi, C., Ganas, A., Dimoyiannis, D., Valmis, S., Lekkas, E. (2012) Catchment-wide estimate of single storm interrill soil erosion using an aggregate instability index: A model based on geographic information systems. Natural Hazards, 62 (3), pp. 863-875
[128] Vafeidis, AT, Drake, NA, Wainwright, J. (2007) A proposed method for modelling the hydrologic response of catchments to burning with the use of remote sensing and GIS. Catena, 70 (3), pp. 396-409
[129] Vaiopoulos, D., Nikolakopoulos, K., Skianis, G., Korompilis, G., Antonakakis, A. (2002) Erosion risk and desertification risk at Pyrgos, Greece. Management Information Systems, CONFERENCE pp. 235-243
[130] Valmis, S., Dimoyiannis, D., Danalatos, NG (2005) Assessing interrill erosion rate from soil aggregate instability index, rainfall intensity and slope angle on cultivated soils in central Greece. Soil and Tillage Research, 80 (1-2), pp. 139-147
[131] Van Andel, TH, Gallis, K., Toufexis, G. (1995) Early Neolithic farming in the Thessalian river landscape, Greece. Mediterranean Quaternary river environments, BOOK J. Lewin, M.G. Macklin, J.C. Woodward (Eds.), Mediterranean Quaternary River Environment, Rotterdam (1995), pp. 131-143
[132] Vött, A., Brückner, H., Handl, M., Schriever, A. (2006) Holocene palaeogeographies of the Astakos coastal plain (Akarnania, NW Greece). Palaeogeography, Palaeoclimatology, Palaeoecology, 239 (1-2), pp. 126-146
[133] Vousaros, A., Romanos, L., Koroxenidis, N. (1983) The state of research into soil erosion in Greece. Soil erosion. Abridged workshop proceedings, Florence, October 1982 BOOK pp. 42-44
[134] Weingartner, H., Karnassioti, A., Vavliakis, E. (2001) Landschaftsdegradation in Nord- und Zentralgriechenland - Regionale Beispiele | [Land degradation in Northern and Central Greece - Regional examples]. Petermanns Geographische Mitteilungen, 145 (4), pp. 56-67

[135] Xeidakis, G., Delimani, P., Skias, S. (2006) Sea cliff erosion in the eastern part of the North Aegean coastline, Northern Greece. Journal of Environmental Science and Health - Part A Toxic / Hazardous Substances and Environmental Engineering, 41 (9), pp. 1989-2011

[136] Yassoglou, N., Kosmas, C., Moustakas, N. (1997) The red soils, their origin, properties, use and management in Greece. Catena, 28 (3-4), pp. 261-278

[137] Zagas, TD, Raptis, DI, Zagas, DT (2011) Identifying and mapping the protective forests of southeast Mt. Olympus as a tool for sustainable ecological and silvicultural planning, in a multi-purpose forest management framework. Ecological Engineering, 37 (2), pp. 286-293

[138] Zaimes, GN, Gounaridis, D., Iakovoglou, V., Emmanouloudis, D. (2012) Assessing soil erosion risk for Rhodes island, Greece with a GIS-based multi-criteria decision analysis. Proceedings of the IASTED African Conference on Water Resource Management, AfricaWRM 2012, pp. 317-324

[139] Zaimes, GN, Emmanouloudis, D., Iakovoglou, V. (2012) Estimating soil erosion in Natura 2000 areas located on three semi-arid Mediterranean islands. Journal of Environmental Biology, 33 (2), pp. 277-282

[140] Zarris, D., Vlastara, M., Panagoulia, D. (2011) Sediment Delivery Assessment for a Transboundary Mediterranean Catchment: The Example of Nestos River Catchment.

2. Waste and Pollutants from Diffuse Sources (Non-Point) in Buzau River, Romania

The Romanian pilot area of the project is represented by the main course of the Buzau River from the border with Covasna county and downstream by the Patarlagele locality, including the Siriu Reservoir. The selection of the pilot area was made having as starting points the following aspects:

- the eligibility criteria of the program has been met in terms of the project area;
- the Siriu reservoir has as main use the use of water for drinking purposes, thus ensuring drinking water for a series of localities downstream;
- identifying some problems regarding the accumulation in the Siriu dam area of a significant quantities of waste transported by the Buzau river, especially during periods of floods and their collection actions by ABABuzau-Ialomita representatives hampered by the lack of high-performance equipment in this domain;
- the need for awareness-raising activities regarding the effects of lack of water or the use of water of inadequate quality, the importance of keeping surface water clean, following simple rules on waste collection and storage in a specially designed place, the consequences of storage waste on the banks of rivers and lakes for humans and the aquatic ecosystem in general and specifically in the pilot area of the project.

The significant pressures acting on the surface water bodies in this area come from two main sources. The first of these, the most visible, is point pollution. This means that the source of pollution is a clear one that can be identified: a sewer pipe that flows into a river, a landfill, etc. In these situations, once the source of pollution is discovered, the necessary measures can be taken.

In addition to point pollution, however, there is also diffuse pollution, which is much more difficult to control because its sources are often impossible to locate. The point sources with impact on the watercourse are the discharges of domestic water and the deposits of household waste, and the diffuse ones are represented by the very presence of the localities but also by the unauthorized deposits of household waste.

On the Buzau River, upstream of the pilot area there are several human agglomerations such as the city of Intorsura Buzaului (9326 inhabitants), Sita Buzaului (4861 inhabitants), Vama Buzaului (3220 inhabitants) which will be taken into account in the activity of identification of the hotpoints in the pilot area of the project.

Within pilot area there are several localities, the first being located on the Buzău river valley in the Siriu Mountain, close to the border with Covasna County, upstream of the tail of Siriu reservoir, namely the village of Gura Siriului which is part of Siriu commune with only 24 inhabitants. The locality does not have a wastewater collection and treatment network. Downstream of the Siriu Reservoir are the villages of Lunca Jaristei, Casoca, Muscelusa and Coltu Pietrii from Siriu commune with a population of about 3187 inhabitants. The locality does not have a wastewater collection and treatment network. From the point of view of waste, these localities represent diffuse sources of pollution. Downstream of these localities are located the other localities that are part of the Nehoiu City: Bîsca Rozilei, Chirleşti, Curmătura, Lunca Priporului, Mlăjet, Nehoiu, Păltineni, Stănila, Valea Nehoiului and Vineţişu (12600 inhabitants). Only Nehoiu locality has a centralized network for wastewater collection and treatment, the other localities are not yet connected to it (representing diffuse pollution sources in terms of human agglomerations). Following the Buzau River downstream, there are other localities belonging to the Patarlagele City with a population of 7304 inhabitants: Muscel, Pătârlagele (residence), Poienile, Sibiciu de Sus, Stroeşti, Valea Lupului, Valea Sibiciului and Valea Viei, Calea Chiojdurile, Gornet, Lunca, Mănăstirea and Mărunţişu.

Only Patarlagele locality has a centralized network for wastewater collection and treatment, the other localities are not yet connected to it (representing diffuse pollution sources in terms of human agglomerations). These point pollution sources are considered potentially significant pressures whose impact is highlighted by monitoring the receiving surface water bodies. Following the monitoring and evaluation of their ecological status / potential, it resulted that the surface water bodies included in the pilot area and those tributary to the Buzau River are in good ecological status/potential as shown in the map below. The goal is to maintain the good ecological status and potential of the water bodies and the project will help to do it (which is one of the main objectives of Water Framework Directive 2000/60/CEE (WFD), the most important European directives in water field).

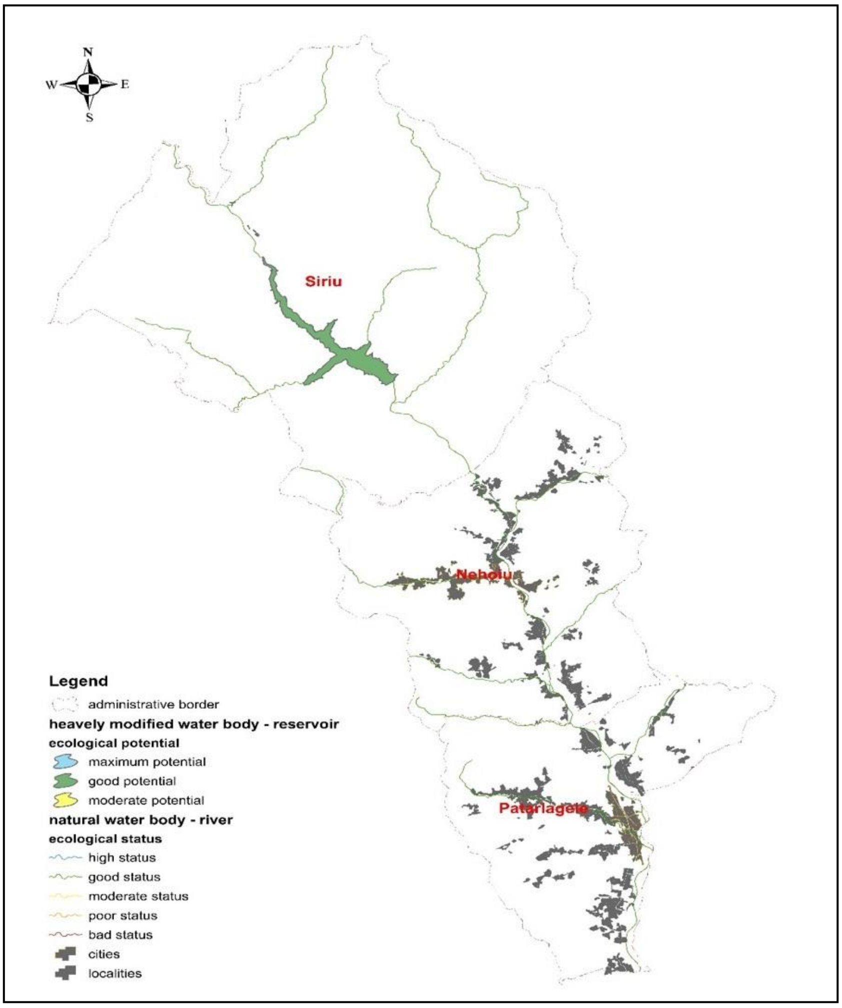

Figure 2.1. The evaluation of the ecological status/potential of the water bodies within pilot area

Diffuse pollution is the result of the discharge of small amounts of pollutants into the environment, but in large areas and very often. Cumulated, all these discharges amount to as large amounts of pollutants as point sources. Inadequate storage of household and industrial waste on inadequate land/ space (e.g. on the banks of watercourses) is a significant source of water and soil pollution in the area of these localities. Other diffuse sources, such as those in agriculture, have a low impact given that intensive agriculture is not practiced in the area.

An important source of household waste is tourism activities. The tourist development of the area has led to an increase in the amount of waste that often ends up in the Siriu Reservoir or in the Buzau River. In the pilot area of the project there are several guesthouses and hotels that can generate different types of waste (plastic, paper, glass, etc.).

Due to the urban development and the increase of the living standard of the population, it led to the production of large quantities of waste. The more and more varied content of these wastes makes the process of degradation and natural elimination, through the action of microorganisms, to be more and more difficult, determining the increase of their remanence period.

The waste management legislation has imposed in all upstream localities and in localities from the pilot area, the application of a sustainable waste management system, which involves the collection, transport, recovery and disposal. These activities are the responsibility of local administrations.

Thus, according to the Agency for Environmental Protection Buzau, an institution authorized in the field in environmental quality assessment and management, there are no authorized landfills in the pilot area, the collection of household waste is done directly from residents through salubrity services from other localities. Upstream of the pilot area there is a transfer station in Intorsura Buzaului, where waste collected from the population is stored for a certain period of time until it is taken over for recycling or disposal of sanitation companies from the regional level. From the reports of the Agency for Environmental Protection Buzau it is found that from the total amount of municipal household waste a small fraction is collected selectively (plastic, paper, glass, metal packaging) as shown in the table no.1 below.

Table 2.1. The situation of selective waste collection

Locality	Year	Selectively collected fractions (kg)				Mixed municipal waste (kg)	% Selectively collected
		Plastic	metal	glass	paper		
Siriu	2018	0,99	0,25	2,063	0,176	3,479	1,49
	2019	0,68	0,2	0	0	0,88	0,47
Nehoiu	2018	0,561	0,05	2,95	4,748	8,309	0,51
	2019	1,464	0,03	12,269	3,475	17,238	1,33
Patarlagele	2018	0,45	0	0	0,64	1,09	0,47
	2019	2,099	0	1,32	0,882	4,301	2,30

The application of a sustainable waste management system involves major changes in current practices. In order to implement these good practices in waste management, it is necessary to involve all social categories: consumers as individuals, institutions, enterprises with economic activities, but also public authorities. Although prevention is the best solution to reduce environmental pressures, waste reduction actions have been rare and often not very effective. Due to the improper storage of household waste and especially plastic waste, after periods of rain and floods, they end up in the Siriu accumulation and during the Buzau River.





Figure 2.2. Pictures regarding the accumulation of waste in the Siriu reservoir and on the banks of watercourses within pilot area

The sources of waste that end up in the Siriu accumulation are the upstream localities, but also the tourist activities on the lake slopes. The presence of this waste can have a negative impact on the operation of the dam, and their persistence can influence the quality of the water in the lake.

According to the Annual Technical Plan for water management, in recent years a series of actions have been carried out for cleaning of the lake. These actions are hampered by the lack of equipment that would make these works more efficient. It was found that the largest amounts of waste accumulate in the spring, when the river flow, but also the level of the lake increase, wash away the banks and slopes.

In order to identify the unauthorized storage areas, periodic actions are taken to verify the sanitation of watercourses, in which institutions in the field of environmental protection and county administrations participate. According to this commission in 2020, the following were identified in the pilot area:

- a landfill and manure on an area of 40 sqm in Lunca Jaristei, Siriu Commune;
- two household and plastic waste dumps (one on an area of 10sqm, another of 80 sqm) in Nehoiu City;
- a landfill for household waste, vegetable waste and plastic (surface of 5 sqm) in Sibiciu de Sus- Patarlagele City.

The measures taken were to clean up the identified areas. The need for better information was identified in order to increase the population awareness of the problems and risks of illegal storage and the urgent need to rationally sort and collect waste for recycling, to capitalize on them as secondary resources.

(1663 m) and the Siriu peak (1659 m).

References

Report on the state of the environment in Romania 2019 - Agency for Environmental Protection Buzau;

***Annual Technical Plan for water management, 2020-Buzau-Ialomita Water Administration;

***Synthesis of surface, groundwater and wastewater quality, 2019 - Buzau-Ialomita Water Administration.

3. Water Resources of the Republic of Armenia and their nonsource pollution

3.1. The water resources of the Republic of Armenia

As an islanded ecosystem Armenia with its isolated geographic location is located in the north eastern part of the Armenian Highlands and covers only 8% of it. Armenia is located much more higher as compared to the surrounding Asia Minor and Iranian plateaus by 600 to 800m above the sea level which is very important in terms of huge climatic differences and alterations. Almost 76.5% of the territory of Armenia is situated at an altitude of 1000-2500 m.

The waters from the Armenian highlands flow into the Kura and Aras River. 14 major river basins include nearly 10,000 rivers and streams and only about 300 of which are more than 10 km in length, including those originating from runoff and springs and others feeding primarily on melting snow and ice. Around 9,500 small and medium rivers flow through the territory of Armenia with a total length of about 25 thousand km. The longest rivers within the borders of Armenia are Akhurian (186km), Araks (158km), Debed (154km), Hrazdan (141km) and Vorotan (119km).

The density of the river network over the country's territory varies widely - between 0 to 2.5 km^2. The rivers of Armenia are characterized by highly disproportionate distribution of flow, both in annual and perennial terms. The average annual flow of surface water is 6.8 billion m3, and groundwater reserves are about 4.0 billion m3.

The Lake Sevan is one of the largest freshwater high-altitude lakes in Eurasia and the only strategic potential source of (near) drinking quality water in the whole Caucasus Region. It stores snowmelt and run-off along with more than 100 small mountain lakes with a total volume of 0.8 km3. The Lake level is 1,900.5 m, the surface area is 1,278.7 km2 and the volume is 38.2 km3 (2017).

All water resources combined in Armenia are sufficient to supply about 3,100 m3 of water per capita annually. Due to significant seasonal and annual fluctuations in the river flow, the temporal and spatial distribution of water resources is extremely disproportionate. To address the seasonal fluctuations in the river flow, 87 reservoirs with a total volume of 1.4 billion m3 have been constructed in Armenia. The average volume of water storage per capita in Armenia is about 465 m3.

Groundwater resources play an important role in Armenia's overall water balance. Armenia's groundwater resources are estimated at 4,017 million m3, of which the approved exploitable reserves are estimated at 1,200 million m3. Groundwater resources play an important role in Armenia's overall water balance. About 96% of drinking water and more than 40% of total water intake are comprised of groundwater. The agricultural sector remains Armenia's largest water consumer.

3.2. Pollution of the Water Resources

Water pollution is the impairment of the beneficial uses of water. Water quality can be adversely affected by direct and indirect sources. Direct sources are fairly obvious and include such practices as dumping waste and hazardous pollutants into streams. Indirect sources are called nonpoint source (NPS) pollution. Stormwater runoff, which may contain fertilizers and pesticides, soil lost from construction sites, and oil residue washed off streets, is NPS pollution. This type of pollution is much more difficult to pinpoint and control.

According to the definition of the US EPA NPS pollution resulting from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification comes from many diffuse sources. It is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters.

Nonpoint source pollution can include:

- Excess fertilizers, herbicides and insecticides from agricultural lands and residential areas
- Oil, grease and toxic chemicals from urban runoff and energy production
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks
- Salt from irrigation practices and acid drainage from abandoned mines
- Bacteria and nutrients from livestock, pet wastes and faulty septic systems
- Atmospheric deposition and hydro modification

According to the World Resources Institute, Armenia is ranked 34th among the 164 UN member states in terms of water stress, as a country with high baseline level of water stress. According to the RA Statistics Committee (SC), the water stress in 2017 was 57.8%.

The level of pollution in the rivers flowing into Lake Sevan is quite high, which significantly affects the ecosystem of the lake, increasing the risk of its swamping. 28 rivers and streams flowing into the Lake Sevan bring with them a large amount of household waste, sewage and agricultural residues. Pollution levels are high, especially in rivers with large populations and existence of no garbage collection systems in the communities. The level of pollution of Lichk, Gavaraget, Martuni, Tsakkar, Dzknaget, Masrik, Karchaghbyur and others is especially high. The same problem exists in developed mining regions, where water resources are negatively impacted by enterprise tailings, industrial effluents and discharges. Debed River Basin is particularly notorious for high level of pollution. The average annual concentrations of aluminum, zinc and copper in the samples taken from the Akhtala estuary exceeded the established norms by 159.5, 408.4 and 932 times, respectively the concentrations of manganese, lead and iron were exceeded 67.2, 11 and 16 times. The same is observed in almost all other rivers. The norm of copper in the Voghji River exceeded 99 times, in Vedi River, below the city of Ararat, the permissible norm of aluminum exceeded 33.5 times.

Accumulations of lead, copper and other heavy metals, which are transmitted through food chains, are especially dangerous. According to the RA and international requirements, the surface water quality class is formed by a comprehensive assessment of the main anions and cations, nutrients, heavy metals and primary organic pollutants.

Nutrients - compounds containing nitrogen or phosphorus (ammonium, nitrite, nitrate, phosphate ions, etc.), which stimulate the growth of algae and can cause eutrophication of water. Their content in surface water can increase due to the presence of communal and agricultural effluents and rainwater. Ammonium ion is formed in natural waters through the decomposition of nitrogen-containing organic matter. High ammonium content may reduce hemoglobin-oxygen binding. Nitrite ion can rise in natural waters if beneficial bacteria fail to prevent their growth. Nitrite poisoning can impair the functioning of the gastrointestinal tract mostly leading to nausea and vomiting. The high content of phosphate ion contributes to the development of skin diseases, then also to the insufficiency of the function of the kidneys, liver and skeletal muscles, which in turn leads to poisoning, metabolic disorders, and exacerbation of chronic diseases.

Heavy metals - molybdenum, mercury, lead, cadmium, copper, alum, etc., deteriorate the quality of water making it unsafe for using for drinking and food making purposes, as well as disrupting the biological processes, reducing the self-purification ability and changing the composition of water. Heavy metals accumulate in producers (mainly green plants) and pass through the trophic chain to humans. Heavy metals occur in natural waters mainly as a result of soil washing, leakage of mining, chemical and metallurgical industries. Heavy metals are dangerous because they leave the human body too slowly. Cadmium – its accumulation affects the nervous system, impairs phosphorus-calcium metabolism. Chronic intoxication leads to osteoporosis, anemia, liver and kidney damage, which can lead to severe kidney failure. Excessive amounts of zinc - salts can lead to nausea and acute intestinal poisoning. Arsenic - in case of high "long-term" exposure can cause injuries of skin and nerve endings, diabetes, cardiovascular disease, as well as cancer. High concentrations of copper can have a toxic effect on living organisms, leading to the tissue growth on some organs, anemia, as well as a number of neurological diseases. High molybdenum content can lead to metabolic disorders.

3.3. Water Quality Norms in Armenia

Surface water quality assessment is carried out in accordance with the Government of the Republic of Armenia decision N75-N dated January 27, 2011, “On defining the water quality assurance norms for each RBD depending on the specifics of the site”.

In the Republic of Armenia, the surface water quality assessment system distinguishes five status classes for each water quality indicator: "excellent" (1st class), "good" (2nd class), "average" (3rd class), "unsatisfactory" (4th class) and "bad"(5th class). The overall assessment of water quality is based on the class of the worst quality indicator. The assessment of the water quality of Lake Sevan and Araks River is still carried out in accordance with the MACs for fish farms.

Groundwater quality assessment is carried out by the order of the Minister of Health of the Republic of Armenia N876 dated December 25, 2002, through comparing generalized indicators and harmful chemicals common in natural waters and MACs of anthropogenic origin. Cereal high-grasses reaching up to 1.0-1.5m in height can be found everywhere in the subalpine zone, and above that, alpine vegetation, which sometimes appears in the form of alpine carpets.

3.4. Water Resources Information

Water intake was carried out from surface and groundwater resources 56.1% and 43.9% of the total amount, respectively. Water transit losses amounted to 787.9 million m3 or 29.0% of water intake. The volume of treated wastewater amounted to 612.1 million. m 3: About 28.0% of the total amount of harmful substances in the treated wastewater are sulfates, 23.4% - suspended solids, 19.2% - BOD, 15.5% - chlorides, 10.9% - COD, and 3.0 % other substances.

The surface water monitoring network includes 144 observation points of water bodies (rivers, reservoirs, Arpa-Sevan tunnel and the Lake Sana) of 6 watershed management areas of the Republic, from which 903 samples were taken in 2019.

According to data provided in 2019, 26.5% of RA rivers are rated 2nd class ("good" quality), 40.8% were rated 3rd class ("average" quality), 11.2% were rated 4th class ("Poor" quality) and 21.4% were rated 5th class ("poor" quality).

The main sources of water pollution are municipal waste, food industry, mining, and agricultural wastewater. In the existing treatment plants, only mechanical treatment is carried out; communal and domestic wastewater is discharged to surface water bodies without treatment. Untreated municipal wastewater carries large amounts of nitrogen-phosphorus compounds to water bodies.

According to the results of surface water quality monitoring carried out in 2019, at the estuary and the sections above the settlements the water quality of the RA rivers is "good" or "average" (2nd or 3rd class). The confluence of untreated municipal wastewater from large settlements and cities induces increased pollution, while water quality is "moderate" to "poor" (3-5 classes) due to ammonium andphosphate-nitrite ions. Pambak River is especially polluted after Vanadzor, Hrazdan River after Yerevan up to the estuary, Akhuryan River after Gyumri, Karkachun River at the river mouth, Metsamor River after the confluence of Kasakh River at the mouth of the estuary, Kasakh river after the city of Aparan, the Getar and Marmarik rivers in the estuarine sections, the Vararak river below Goris town and Yerevanian Lake.

Akhtala River at the river mouth, Debed River near the border above Ayrum, Shnogh, Achanan (Norashenik), Karchevan rivers at the estuary, Voghji River below Kapan town, where the water quality is assessed as "poor" (5th lesson) is due to mining activities and pollution of water with heavy metals. Sotk River is also polluted by the mining industry.

3.5. Conclusion

Keeping in mind the fact that water is the “future Gold” because of the ever growing water demand by the population and the climate change the humanity needs to address the water pollution problem. The efforts to reduce nonpoint pollution depend on the precise land use mix and involve a potentially large, diverse group of stakeholders and private landowners. Nonpoint is a particularly challenging governance dilemma described by Yoder (2013) as a “collective-action puzzle”.

The complexity of nonpoint pollution creates uncertainty and raises the costs of abatement. Finally, nonpoint pollution crosses multiple scales from the farm or household to the river or lake, requiring local action and landscape level coordination across political jurisdictions. The complexity of nonpoint pollution has made it a prime focus for adaptive water governance. Adaptive water governance brings together two separate but complementary streams of thinking: adaptive co-management and water governance. Adaptive management is based on experimentation coupled with the flexibility and mechanisms to shift course in response to learning from diverse forms of knowledge. This iterative learning characteristic of adaptive management, when coupled with the linkage dimension of collaborative management, results in adaptive co-management. Water governance, on the other hand, has become closely linked with inclusion of new actors and informal institutions, collaboration and bioregionalism, i.e., the alignment of political and natural boundaries. Together, adaptive management and water governance promote “cross-level linkages, the conditions for partnerships that really share power, and ways to move from instrumental learning to learning about appropriate goals”. Despite its intuitive appeal and potential benefits, adaptive water governance is notoriously difficult to pin down in practice. A number of recent studies attempt to operationalize the concept through indicators that can be measured at a range of scales in relation to various challenges, such as climate change and environmental quality.

Thus it should be born in mind that complicated problems require complex solutions, with step-by-step approach starting from the easiest ones on the citizen-scale and continuing to the complex solutions on trans-boundary level, including:

- Training and awareness rising of the population on nonpoint pollution sources, pollution control

- Limitation of the use of pesticides and fertilizer at appropriate times of the year in recommended amounts. Introduction of natural predators to garden, and use of pest resistant plants. Removal of eggs, larvae, cocoons, and adults from plants by hand.

- Prevention of erosion by covering bare soil with vegetation and mulch.

- Organization and participation in a stream cleanup program.

- Removal of obstructions from stream channels and re-vegetation of stream banks.

- Envisaging a buffer of tall grasses or shrubs to filter pollutants along the water bodies.

- Landscaping yards to minimize rainwater runoff.

- Preservation of neighborhood trees that help minimize the damage caused by surface runoff.

- Placing retaining walls or diversions on steeply sloping ground to reduce the rate of water flow and erosion.

- Disposing of litter in garbage cans or in recycling bins. Recycle glass, aluminum, plastic, paper, motor oil, and newspapers.

- Composting yard and garden waste.

- Not dumping anything into a storm drain

- Establishment of treatment plants, equipping the existing ones with new technologies, usage of biotechnology, as well as establishing control over their work.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

References

1. ArmStat , statistical data sources
2. Environmental Monitoring and Information Center SNCO, Ministry of Environment of the Republic of Armenia, reports about the state of the environment
3. H.K.Gabrielyan “Armenian Highlands”, Yerevan 2000
4. Abrahamyan H., Simonyan A., Tokmajyan H., Sargsyan V., Perspectives on the use of water resources in the Republic of Armenia,
5. The fourth National communication on climate change,
6. https://tamlime.wordpress.com/2012/11/06/, The rivers of Armenia are dangerous,
7. Report- surface water quality in the Republic of Armenia in 2019, Hydro-meteorology and monitoring center
8. Hardy, S. D., & Koontz, T. M. (2008). Reducing nonpoint source pollution through collaboration: Policies and programs across the US states. Environmental Management, 41(3), 301–310.
9. Yoder, L. 2013. Exploring Farmer Best Management Practices and Collective Action to Reduce Nonpoint Source Pollution. Paper Presented at the Ostrom Workshop Y673 Seminar Mini-Conference. Bloomington: Indiana University.
10. Huitema, D., Mostert, E., Egas, W., Moellenkamp, S., Pahl-Wostl, C., & Yalcin, R. (2009). Adaptive water governance: Assessing the institutional prescriptions of adaptive (co-) management from a governance perspective and defining a research agenda. Ecology and Society, 14(1), 26.
11. Pahl-Wostl, C. (2007). Transitions towards adaptive management of water facing climate and global change. Water Resources Management, 21, 49–62.
12. Huitema, D., Mostert, E., Egas, W., Moellenkamp, S., Pahl-Wostl, C., & Yalcin, R. (2009). Adaptive water governance: Assessing the institutional prescriptions of adaptive (co-) management from a governance perspective and defining a research agenda. Ecology and Society, 14(1), 26.

4. Soil and Water Pollution in Dniester River's Basin - Moldova

4.1. Introduction

Soil pollutants, as defined by WHO experts, are chemicals, biological organisms (bacteria, viruses, protozoa, helminths) and their excreta that occur in the wrong place, at the wrong time and in the wrong amount. Soil contamination should be understood only as the content of chemical and biological pollutants in it, which becomes hazardous to health during direct human contact with contaminated soil or through environment in contact with the soil, along the ecological chains: soil - water - human; soil - atmospheric air - human; soil - plant - human; soil - plant - animal - human, etc.

The soil can be contaminated as a result of:

1) Application of mineral and organic fertilizers;

2) The use of pesticides;

3) Input of industrial and household waste of various types, which are used as fertilizers and for the purpose of moistening, including the introduction of waste of livestock complexes (farms) and individual farms into the soil;

4) Transfer on its surface of chemicals with atmospheric emissions from industrial enterprises and vehicles, as well as radionuclides due to accidents at nuclear reactors;

5) Burial of household and industrial waste [1-6].

All soil contaminants can be divided into biological (viruses, bacteria, helminth eggs, protozoa) and chemical. Soil chemical contaminants fall into two large groups. The first group includes chemicals that are purposefully introduced into the soil, most often in agriculture and forestry: pesticides, mineral fertilizers, soil binders, plant growth stimulants, etc. This process is controlled. In case of non-observance of agrochemical and hygienic regulations for the use (introduction of excess into the soil) of exogenous chemical substances into the soil, they become soil contaminants and can threaten human health.

The second group of chemical pollutants includes chemical substances that enter the soil accidentally with technogenic (anthropogenic) liquid, solid and gaseous waste. These are substances that enter the soil along with domestic and industrial wastewater and solid waste, atmospheric emissions from industrial enterprises, exhaust gases from vehicles, etc.

4.2. Materials and Methods

Investigations of soil pollution were carried out in the Balcata river basin, by photographing the main sources of pollution. Photo by Kuharuk Ekaterina and Crivova Olga. The research was carried out according to the methodology used in Europe [7].

This book shows traditional methods of studying basic soil properties. These methods are of particular value in connection with the development of environmental monitoring of soil and water resources. For water resources, "Water Expertise and Analysis" is used [8].

4.3. Results and Discussion

The following driving forces (activities) and anthropogenic loads affecting the ecological state are identified in the Moldovan District of the Dniester River basin:

Housing and municipal services:

- Domestic and municipal water withdrawal;
- Pollution of surface and ground waters by organic and biogenic substances;
- Pollution by domestic and municipal waste.

Industry (including petrochemical, pulp and paper, food and beverage industries):

- Water withdrawal;
- Pollution of surface and ground waters by hazardous substances;
- Accidental pollution and impact of contaminated sites.

Agriculture, including fish farms:

- Water pollution by pesticides, organic and biogenic substances;
- Invasive species, poaching.

Hydropower industry:

- Disruption in natural river flow and migration of aquatic organisms;
- Changes in hydrological and temperature regimes.

Flood mitigation:

- Morphological changes.

The following problems and their causes were identified based on the above-mentioned activities and loads:

1. Organic pollution due to insufficient wastewater treatment or lack thereof.

2. Contamination with biogenous materials due to insufficient wastewater treatment or lack of it, and also due to washoff from agricultural land.

3. Pollution with hazardous substances, the sources of which are municipal and industrial waste discharge, rainwater runoff, pesticides and other hazardous chemicals used in agriculture; also including accidental pollution and the impact of contaminated sites.

4. Hydromorphological changes associated with hydropower, flood protection, and the degree of river flow control.

5. Pollution by plastic and other household wastes [10].

The main cause of contamination with organic substances is insufficient degree of wastewater treatment or lack thereof. Organic pollution can lead to significant changes in the oxygen balance of surface waters and, as a consequence, to a change in the species composition of aquatic organisms or even their death. The intake of organic matter with wastewater is usually assessed by indirect indicators of BOD and COD.

Biogenic pollution, in particular nitrogen (N) and phosphorus (P), stimulates eutrophication of surface waters. The main sources of input are untreated wastewater from municipal services and industrial plants. The widespread use of phosphorus-containing washing powders and detergents along with insufficient wastewater treatment increases pollution with biogenous matter.

The total load of biogenic materials on river systems is conditioned both by their discharge from point sources and by input from diffuse sources, which, in accordance with the landscape characteristics of sub-basins, are distributed in different ways. At the same time, part of the pollutants (from 15 to 25% - nitrogen and from 50 to 65% - phosphorus) is retained in the sub-basins, and part of them goes directly to the Dniester river.

According to CROSS-BORDER EXPLORATORY ANALYSIS OF THE DNIESTER RIVER BASIN [10] values were taken for biogenic discharge in the basins of the main right tributaries of the Dniester river- Raut, Bac and Botna. The runoff from 1 km2 was calculated in each basin of these rivers from the non-point sources, and on the basis of these data, an extrapolation of the average value for the runoff of nitrogen and phosphorus to the pilot territory of the Baltata river basin was made. Known value data and extrapolation are presented in the table (Table 4.1).

Table 4.1. Biogenic pollution of the Central Moldova river tributaries of the Dniester basin

	TRIBUTARIES	Basin's area, km^2	Nitrogen's annual runoff, tons		Phosphorus annual runoff, tons		Diffuse sources, runoff per 1 km^2, tons	
			Total	Diffuse sources	Total	Diffuse sources	N	P
1	Raut	7760	2 381	2 273	223	221	0,29	0,03
2	Botna	1540	250	246	38	37,7	0,16	0,02
3	Bac	2150	1 948	392	441	114	0,18	0,05
4	Baltata*	153,9	70,79	32,32	13,34	4,62	0,21	0,03

* Extrapolation of data is based on values for runoff per 1 km2 from non-point sources of the Raut, Botna and Bac rivers.

Plastic pollution is one of the most significant anthropogenic loads in Dniester River's basin. According to the National Bureau of Statistics of Moldova, from 2014 to 2015, the volume of waste more than doubled: from 1.8 million tons to 3.98 million tons. At the same time, the volume of recycled waste had even decreased: from 622 thousand tons to 609 thousand tons.

For the rivers of the basin, this problem manifests itself in:

• Unauthorized landfills on the banks from which garbage, and especially plastic products, gets into rivers and is carried by the current;

• Floating and sunken debris, primarily plastic products (bottles, bags, disposable dishes, etc.);

• Microplastic.

Macroplastic, disintegrating, turns into microplastic, which enters the food chain of aquatic organisms, contributing to the accumulation of toxins in them. Microplastics are commonly referred to as plastic particles smaller than five millimeters. It can be divided into two main groups - primary and secondary. Primary microplastic occurs when car tires are worn out, when synthetic fabrics are washed.

In addition, small plastic granules are often added to cosmetics (such as toothpaste and shower gels) and industrial cleaners for a better cleaning effect. During use, they are flushed down the drain along with waste water.

Recycled microplastics come from large plastic debris. Discarded bags, disposable dishes, bottles and other waste will gradually disintegrate into smaller pieces.

Microplastics enter food chains when they are eaten by animals (from zooplankton to fish and birds) and can accumulate in the tissues of living organisms. Plastics often contain toxic admixtures, such as dyes and flame retardants, which, when released into the digestive system of animals, can cause intestinal inflammation and affect reproduction. In addition, microparticles easily adsorb other toxic substances, such as pesticides and dioxins, and then release them into the body in which they enter. Taking into account the significant number of unauthorized landfills on the banks of the rivers of the Dniester basin in Moldova, and the low percentage of recycling plastic waste, it would be right to assume that this problem is urgent in this given river basin[10].

We present a photo of the main pollutants in the territory of the Baltata River's basin. These are the various household wastes: construction waste, films, organic matter from household animals, chemicals, household waste in the river floodplain (photos 4.1-4.2). Household waste affects the chemical composition of the soil, causing deterioration in its quality. The wells of Moldova have 90% of poor quality water. Massive pollution of wells is explained by the form of farming: animals are raised near water sources, there are no sewerage and treatment systems (Photo 4.3). All waste goes to the soil and groundwater, and from the soil to wells. Moldova occupies on one of the last places in Europe on the quality of surface water (Table 4.2, 4.3), the data on hydrochemisrty of Baltata River's water is provided by State Hydrometeorological Service (SHS) and Academy of Sciences of Moldova (ASM)

Photo 4.1. The household wastes: construction wastes (left), films (right).

Photo 4.2. The household wastes: organic matter from household animals (left), chemicals (right).

Photo 4.3. The rural wells on the Territory of Baltata River's basin.

Table 4.2. Hydrochemical parameters of the water from Bălţata River at the water station from Bălţata village.

Sourse	Years	CCO-Mn, mg/l	CCO-Cr, mg/l	Mg, mg/l	Cl, mg/l	Sulphates, mg/l	Sum of ions, mg/l	Hardness, mg-eq/L	Hydrocarbonates, mg/l	Na, mg/l	K, mg/l
SHS	1999-2001	2,84 - 6,8	23,5	22,5 - 123	22,5 - 93,4	142 - 760	481 - 1158	4,53 - 19,58	187 - 395	132	13,8
ASM	2018	9.12	58.75	143.5	116	863.3	2128	22.6	582.7	Na+K = 205.3	

Table 4.3. Hydrochemical parameters of the water from Bălţata River at the water station from Bălţata village

Sourse	Years	Ca, mg/l	Na+K, mg/l	Ammonium ions, mgN/l	Nitrites, mgN/l	Nitrates, mgN/l	Mineral phosphorus,	Total iron, mg/l	Silicon, mg/l
SHS	1999-2001	53,7 - 188	53 - 120	0,43 - 1,68	0,054 - 0,34	0,2 - 6,18	0,192	0,04 - 0,08	2,9 - 3,2
ASM	2018	216.4	205.3	0.69	0.34	8.65	0.31	1	10.97

Carbonate chernozem contains carbonates throughout the soil profile (photo 4.4 left), which deteriorate the quality of drinking water, increase its hardness and thus it can only be used after boiling, when salts precipitate. Therefore, the information should be provided about poor-quality water for the population (photo 4.5 right)

Photo 4.4. left) Carbonate chernozem increases the hardiness of water in the wells, right) The well with unpotable water (sign reads: "Water is potable after boiling")

The water of some wells can only be used for technical water supply due to the high concentrations of fluorine, nitrates and sulphates. The treatment facilities of the Kellers brewery in Moldova are outdated. Wastewater from this plant contaminates soil and groundwater and flows out under the bridge, flowing tens of meters on the floodplain soils (photos 4.5 and 4.6).

Photo 4.5. left) Kellers brewery facilities in Budesti Village, Chisinau mun, right) Waste waters discharge pipe

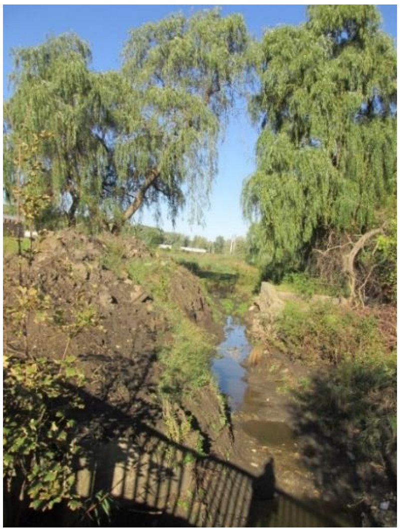


Photo 4.6. left) Waste waters from Kellers brewery waste treatment facilities, flowing under the bridge, right) Waste waters from Kellers brewery waste treatment facilities, discharged on the floodplains soils

Most of the urban agglomerations in the Dniester River basin are connected to municipal wastewater treatment plants. Wastewater collection in rural and urban settlements is carried out in individual septic tanks or cesspools, which are one of the potential sources of pollution of underground water-bearing strata in the Dniester River's basin. Organic pollution from non-point sources of pollution is mainly determined by rural households not connected to sewerage networks. Water disposal in those individual farms is carried out by accumulation in sedimentation tanks, from which wastewater is filtered into the nearest groundwater horizons. Small doses of fertilizers increase the yield of crops, but very often farmers violate the rules for applying fertilizers. Fertilizers and pesticides are used in greenhouses located near water bodies. Polluted effluents enter the groundwater and are then carried into the Baltata River's basin (photos 4.7). Protection of soils from wind and water erosion - forest belts that are planted in fields according to the land management (photos 4.8). The high temperature of 2020 affected the blooming of water in lakes and reservoirs (photos 4.9).


Photo 4.7. The lack of modern sewerage system in Baltata river's basin: Outdoor shower and toilet, animal manure polluting the ground waters.


Photo 4.8. Forest belts on agricultural lands

Photo 4.8. left) Green algae water bloom on the lake, right) The result of pollution by waste waters.

Green water bloom is caused by cyanobacteria or blue-green algae. Two factors are favourable for their vital activity - warm temperature and the presence of biogenic elements: phosphorus and nitrogen. Phosphorus and nitrogen enter water bodies and lakes along with sewage, waste, and fertilizers - this is the main breeding ground for algae. The main danger arises when the algae die off. When decomposing, they absorb all the oxygen contained in the water and release toxins that are harmful to other organisms. In such water, all living things die, except for new generations of cyanobacteria. The water becomes unusable. The fish dies, and the toxins are dangerous for humans. The problem of blue-green algae is currently characteristic for almost all water bodies of Moldova.

The second problem of water pollution is microplastic pollution - these are particles less than 5 millimeters in size. They are found in modern shampoos, toothpastes, cleaning products and detergents. They are specially included in the composition of household chemicals to improve their consumer properties. But there is no technology for their wastewater treatment in the world. Particles of microplastics enter water bodies through the treated sewage system. There is also secondary microplastic: it is formed when large fragments of debris (bags, plastic bottles, etc.) that float in water bodies break down. As a result, microplastics end up in the water that we drink and penetrate into our body [9]. Another way is through the consumption of fish. The smallest particles of plastic are embedded in food chains through the communities of living organisms, they have a high penetrating ability.

4.4. Conclusions

1. The territory of the Baltata River's basin has an accumulation of household waste issue; the reduction in the number of household landfills, the problem of waste disposal is far from being solved.
2. It is necessary to carry out a chemical analysis of pollution from industrial waste of the Kellers brewery and mark the territory of pollution.
3. It is necessary to design sewerage and water supply systems in the villages

of the Baltata river's basin.

4. Floodplain wetlands can be used in the future for sites of wetlands that would provide habitat for wildlife (photos 4.9).


Photo 4.9. Floodplain wetlands in Baltata River's basin.

4. To conduct identification of sources of pollution in the recreation area Vadul-lui Voda and microbiological analysis of water is imperative (photos 4.10).



Photo 4.10. Runoffs of the recreation centers in Vadul-lui-Voda into the Dniester River

References

[1] KUHARUK, E.S. Cartometric studies of soils of in Moldova for protection of nature. In: International conference “Youth and ecology”, Кишинев, 1991. С.34-37.

[2] DRUMEA, D.A.; ILAȘCU, L.K.; KUHARUK, E. S. Options for the implementation of the European Union Water Fraemwork Directive in Moldova. In NATO Advanced research Workshop” Modern Tools and Methods of Water Treatment for Improving Living Standards”, Ukraine, November, 19-28, 2003. P.20-21.

[3] KUHARUK, E.; STEGĂRESCU, V.; LIOGHII, N.; CRIVOVA, O. Soils ecological functions degradation and influence over environment. B.: Natural cataclisms and global problems of the modern civilization. Baku-Innsbruck, 2007. P. 394-398.

[4] KUHARUK, E.; SUMLEANSCAIA, E. Aquatic resources and conservation of ecosystems in the Republic of Moldova. 37th IAD Conference “The Danube River Basin in a changing World”. Book of Abstrasts, Chișinău, 2008. P. 30.

[5] BURGHELEA, A.; BULIMAGA, C.; KUHARUK, E.; MOGÂLDEA, V. Impact of waste on soil cover in Chișinău urban ecosystem. AES Bioflux, V. 5, 2013. ISSUE 2. P.239-244. Print. Internet conf. Cluj – Napoca, 2013. ISSN 2065-7647.

[6] КУХАРУК Е.С. Soils of Dniester River and its impact on water quality {Почвы бассейна реки Днестр и их влияние на качество воды]. (In Russian). Материалы научно-практической конференции «Агроэкологические проблемы почвоведения и земледелия». Курск, 2019 http://vniizem.kurskfarc.ru/novosti/12-novosti-instituta/492-25-aprelya-2019-goda-kurskoe-otdelenie-moo-obshchestvo-pochvovedov-im-v-v-dokuchaeva-i-fgbnu-kurskij-federalnyj-agrarnyj-nauchnyj-tsentr-proveli-mezhdunarodnuyu-nauchno-prakticheskuyu-konferentsiyu-agroekologicheskie-problemy-pochvovedeniya-i-zemledeliya

[7] Soil Science: Methods and Applications/David L.Rowell, Department of Soil Science, University of Reading Longman Group UK Limited, 1994 ,486 стр. ISBN 0-582-08784-8

[8] Экспертиза и анализ воды 8(495) 151-84-77 .eco-defence.ru

[9] POPs – the challenge of XXI Century. (In Russian). Стойкие органические загрязнители – проблема всех и каждого в XXI веке. Кишинёв, Eco-Tiras: 2005.-P. 14. ISBN 9975-9817-4-7

[10] CROSS-BORDER EXPLORATORY ANALYSIS OF THE DNIESTER RIVER BASIN/ ТРАНСГРАНИЧНЫЙ ДИАГНОСТИЧЕСКИЙ АНАЛИЗ БАССЕЙНА РЕКИ ДНЕСТР, Днестровская комиссия, Кишинёв-Киев, 2019, 160 с. [In Russian]. https://dniester-commission.com/en/news/the-transboundary-diagnostic-analysis-for-the-dniester-river-basin-issued/

5. An Important Ecological Problem in Black Sea: "Marine Debris"- Turkey

5.1. Introduction

"Marine litter is defined as any persistent, manufactured or processed solid material discarded, disposed or abandoned in the marine and coastal environment" (Coe and Rogers, 1997; Galgani et al., 2010). It consists of items that have been made or used by people and deliberately discarded into the sea or rivers or on beaches; brought indirectly to the sea with rivers, sewage, storm water or winds; accidentally lost, including material lost at sea in bad weather (fishing gear,cargo); or deliberately left by people on beaches and shores (UNEP, 2009; Iñiguez et al., 2016).

Marine debris, also known as marine litter, is human-created waste that has been either deliberately or accidentally released in a river, lake, sea, ocean or waterway. Floating oceanic debris tends to accumulate at the center of gyres and on coastlines, frequently washing aground, when it is known as beach litter. Deliberate disposal of wastes at sea is called ocean dumping. Naturally occurring debris, such as driftwood, are also present.

Sea debris or sea litter is also defined as debris that produced by human and reaches sea by rivers, sea waves, storms, sewages or directly arrives sea coast (URL-1, 2020). Plastics, wood pieces, metals, glass, clothes, paper etc. are common sea debris (Corcoran et al., 2009). From these, plastics and synthetic materials are the most common types (Allosp et al., 2006). Annual amount of sea debris in the World is estimated to be 6 million tonnes (UNEP, 2005). Sea litters not only cause ugly views but also negatively affect human and marine ecosystem health.

The presence of marine debris is a cause for concern due to several reasons. It is known to be harmful to organisms and to human health (Coe and Rogers, 1997; Derraik, 2000; Gregory, 2009, Rochman et al., 2013), it has potential to increase the transport of organic and in organic contaminants (Gaylor et al, 2012; Holmes et al., 2012 Mato et all., 2001; Rochman et al., 2013; Teuten et al., 2009), it presents a hazard to shipping, and it is an esthetically detrimental, and thus generating negative socio-economic consequences (Mouat et al., 2010).

Litter may easily be mistaken as food by animals and cause health complications or even death. Many studies have investigated the ingestion of plastic items by marine animals, including fish, cetaceans (Baulch and Perry, 2014), turtles (Lazar et al., 2011) or seabirds (Azzarello and Van Vleet, 1987; Ryan and Jackson, 1987). Fishing gear can be come ocean pollutant as a result of accidental losses or dumping. Entanglement in abandoned fishing gear is another important threat not only for marine mammals (Laist, 1997; Schrey and Vauk, 1987), but also for benthic biota (Chiappone et al., 2005; Iñiguez et al., 2016).

The material most commonly found in marine debris are glass, metal, paper and plastic(OSPAR, 2007), and, according to the publish literature, it is clearly apparent that, globally, plastic items are consistently the most abundant type of marine debris (UNEP, 2009; Iñiguez et al., 2016; Thompson et al., 2009; UNEP-CAR/RCU, 2009; UNEP, 2005) (Figure 5.1).

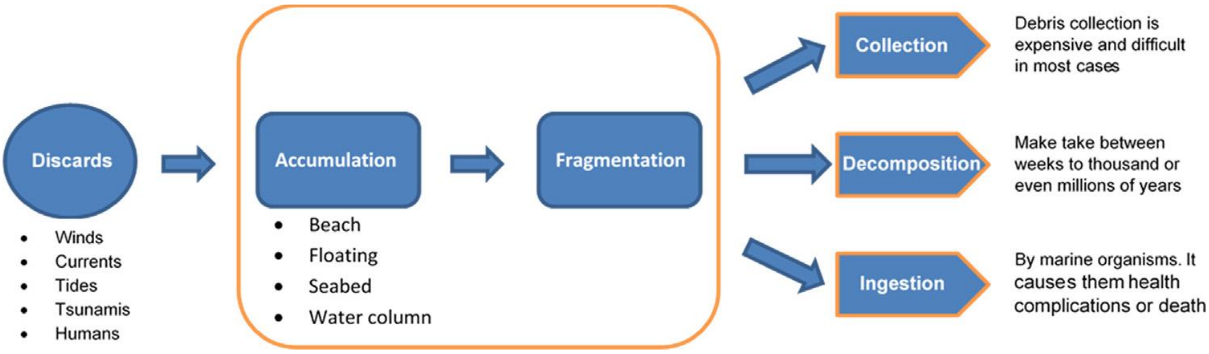

Figure 5.1. Typical lifecycle of marine debris (Iñiguez et al., 2016)

Plastics are the most hazardous to the marine environment due to their irresistance to degradation (Laist, 1987). The natural decomposition of plastic items in the sea occurs in an exceedingly long time, usually estimated between hundreds and thousands of years (Barnes et al., 2009)), therefore, plastics accumulate in the marine environment and persist for years (Katsanevakis, 2008). Chemical contaminants such as polychlorinated biphenyls(PCBs) and dioxins are released into the sea during this degradation. Furthermore, plastic items are fragmented into small pieces, becoming plastic microparticles (with a diameter of less than 5 mm) (Arthur et al., 2009)], which are ingested by animals, thus being very harmful to marine life (Andrady, 2011; Cole et al., 2011).

Plastics have existed only for around a century (Gorman, 1993), but since the development of the plastics industry, plastic products are the most abundant around the globe, hence representing 60-80% of the total marine debris (Gregory and Ryan, 1997). A compilation on the proportion of plastics found in the marine debris was done 15 years ago (Derraik, 2002). Table1 presents new data on the same subject published from then. An average value of >65% of plastics in the rubbishes found, denoting the importance of controlling the plastic deposition in all places around marine environments, such harbors, beaches, and those from the fishing and recreational activity (Iñiguez et al., 2016).

5.2. Current Situation in Black Sea

The Black Sea is one of the best examples of a highly stratified inland sea, and has the world's largest anoxic zone (90% of the water column). There is a permanent pycnocline at depths from 35 to 150m (Ivanov et al., 2001) due to surface freshwater outflowing from many large rivers and deeper saline water inflowing through the Bosphorus Strait (Sorokin, 2002; Izdar and Murray, 1991). This pycnocline limit exchanges between surface and deep water, but is the most active zone of the sea in terms of oceanographic characteristics. There is substantial information about the overall oceanography of the Black Sea, and its current environmental state (Bakan and Buyukgungor, 2000). Pollutant loadings to the Black Sea have been described by Zeri et al. (2000) and Tuncer et al. (1998). Considerable parts of the coastal waters along the Southeast Black Sea from Samsun to Rize have been officially declared as heavily polluted and restricted sites for recreation and fishing (Berkun et al., 2005).

The Turkish Black Sea coast is 1695 km long, extending from the Bulgarian border in the west to the Georgia border in the east. Black Sea coasts constitute 20% of the total coastlines of Turkey. Excluding Istanbul, the remaining 14 provinces along the Black Sea coast have a total area of 92,198 km2 and a total population estimated at 8,072,979 in 1990. There are 420 municipalities in the Black Sea Region. Eighty of these municipalities have populations of over 10,000. The region extends over a very large area and shows differences of nature, population, living standards and environmental problems. From this perspective, Istanbul and Trabzon, as the major cities at the western and eastern parts of the Black Sea, respectively, are considered in this analysis to present the solid waste problems of the region (Berkun et al., 2005).

Marine litter is a crucial and complicated environmental problem in the Black Sea basin and it is getting more attention in lately (BSC, 2007). The majority of the litter originates on land and river flow is the main source of litter into the Blacksea (BSC, 2007). The litter input via the Danube River into the Black Sea is estimated at 4.2 t per day (Lechner et al., 2014). In the Turkish Black Sea region, most of the municipal and industrial solid wastes, mixed with hospital and hazardous wastes, are dumped on the nearest lowlands and river valleys or into the sea (Berkun et al., 2005). Results of aerial surveys suggested that a significant amount of marine litter comes to the Russian Black Sea in late spring and early summer (BSC, 2007; Jeftic et al., 2009). Snowmelt and heavy rainfall during this period are thought to be key factors in carrying litter to the sea, as river discharge in this area is usually low at other times of the year (Miladinova et al., 2020).

Vesselbased observations of floating plastic marine litter range from 6.6 to 65.7 items km−2 in the Ukrainian Black Sea and Kerch Strait. High litter densities peaking to 135.9 items km−2 (mean 30.9 ± 7.4 items km−2) were found by vessel-based survey in the north-western part of the Black Sea (Suaria et al., 2015). Plastic is recognized as the dominant marine litter on the Black Sea beaches (Muresan et al., 2018; Simeonova and Chuturkova, 2019), in the sea surface (Suaria et al., 2015), and on the sea floor (Moncheva et al., 2016).

An assessment of beach litter shows that a large amount of debris has been observed in different areas of the southern Black Sea coast (Topçu et al., 2013; Terzi and Seyhan, 2017; Aytan et al., 2019; Oztekin et al., 2020). Identifiable foreign litter belonging to neighbouring Black Sea countries or another external source accounts for about 2.3% of total encountered litter (Oztekin et al., 2020). When the marine litter is classified according to the material types, plastic is the most prevalent type of litter in the Black Sea studies cited above. The southeastern side of the Black Sea was found to be more polluted than its western side (Topçu et al., 2013; Terzi and Seyhan, 2017). Conversely, compared to the eastern side, the western side of the Turkish Black Sea is ~ 3.8 times more populated and hence its marine litter was expected to be denser. An extremely high litter density (1.51 ± 0.58 items m−2) is detected in Sarıkum Lagoon, which is located at about 42°N and 35°E (Oztekin et al., 2020). An even higher litter density with higher variance is estimated for Sarayköy Beach (2.10 ± 1.38 items m−2), which is located at about 41.02°N and 40.38°E (Table 5.1) (Aytan et al., 2019).

Monitoring of marine litter along the Bulgarian Black Sea coast (Simeonova et al., 2017) shows that the beaches are highly polluted due to local sources, where cigarette butts and filters are dominant. Since the highest marine litter accumulation is observed in summer, one can conclude that the accumulation is probably a result of recreational activities, increased tourist flowand, agricultural activities and wild camping.

Table 5.1. Marine litter densities (mean ± SD) in some coastal areas of Turkey (Terzi and Seyhan, 2017)

Region	Density (items/m²)	Plastic (%)	References
South-Eastern Black Sea Coast	0.03–0.58 (0.16 ± 0.02)	61.7	Terzi and Seyhan (2017)
South-Western Black Sea Coast	0.09–3.14 (0.88 ± 0.94)	91.0	Topçu et al. (2013)
Coastal Area of Cilician Basin	0.02–5.15 (0.92 ± 0.36)	80.0	Aydın et al. (2016)

Therefore, the marine litter on the west coast of the Black Sea seems to be almost entirely of local origin. In summary, on the base of existing evidence the litter density on the west coast is less than on the South and east coasts (Miladinova et al., 2020). In a study done by Terzi and Seyhan (2017), the examination of marine litter from combining data from all nine stations revealed that plastic was the most abundant litter accounting for > 60% of the total marine litter on the south-eastern Black Sea coast. Based on seasonal data, the contribution of plastic to the total marine litter varied between 47%-78% by count, and 61%-78% by weight. Also, at each station, plastic accounted for 52%-81% of the total marine litter by count and 67%-81% by weight. They estimated marine litter density (mean ± SD) from combined data as 0.16 ± 0.02 items/m^2 by count and 3.35 ± 1.63 g/m^2 by weight. Seasonal differences were not significant and did not differ from each other at any of the stations. However, spatial variations were evident where marine litter density varied significantly between stations.

5.3. Suggestions to reduce marine debris

Marine debris is an important subject for the oceans around the globe and its getting more attention lately. In order to solve this problem, government departments should try to improve their advertising and even provide incentives to people that recycle (Kou and Huang, 2014). First step should be to reduce single-use plastics. These items include plastic bags, water bottles, straws, cups, utensils, dry cleaning bags, take-out containers, and any other plastic items that are used once and then discarded. Second step is education. Education is also important in order to improve the actual conditions of oceans and could change the habits of people in an effective way, especially starting from childhood (Derraik, 2002). Education about the importance of recycling and caring for the marine environment must be incorporated into the school programs, and schools should organize activities every year to clean nearby beaches (Kou and Huang, 2014). In addition, organizing cleanup activities for kids will reduce marine debris too. Further events should also be organized to educate people in how to treat the environment properly after and during leisure activities on nature. An important part of marine debris is attributed to the fishing industry. It has been suggested that fishermen should follow some guidelines for waste disposal at ports, to use bait containers and implement programs for fishing nets recycling (Iñiguez et al., 2016).

An important measure that is having good result is the restriction on the use of plastic bags. It is intended that people use only the necessary bags. Consequently, governments decided to face in new bagging fees instead of allowing supermarkets to provide free bags. Taiwan has reduced the consumption of plastic bags on a 58.34% with this initiative (EPA, 2014). Other countries, as is the case of France, have banned the use of plastic bags in stores from January 2016 (Iñiguez et al., 2016). Turkey is also charging a fee for use of plastic bags in shopping centers. This way country saved around 200 million dollars in a year time period.

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Protect-Streams-4-Sea

References

Allsopp, M., Walters, A., Santillo, D., Johnston, P. (2006): Plastic Debris in the World's Oceans. 44 page.

Andrady, A.L., (2011). Microplastics in the marine environment. Mar. Pollut. Bull., 62:1596–605.

Aytan, U., Sahin, F.B., Karacan, F., (2019). Beach litter on Sarayköy Beach (SE Black Sea): density, composition, possible sources and associated organisms. *Turk. J. Fish. Aquat. Sci.*, 20 (2): 137–145.

Azzarello, M.Y., Van Vleet, E.S., (1987). Marine birds and plastic pollution, Mar. Ecol. Prog. Ser., 37:295-303.

Bakan, G., Buyukgungor, H., (2000). The Black Sea. *Marine Pollution Bulletin,* 41: 24–43.

Barnes, D.K.A., Galgani, F., Thompson, R.C., Barlaz, M., (2009). Accumulation and fragmentation of plastic debris in global environments. Philos. *Transac. R. Soc. Lond. B: Biol. Sci.,* 364:1985–98.

Baulch, S., Perry, C., (2014). Evaluating the impacts of marine debris on cetaceans. *Mar. Pollut. Bull.,* 80:210–21.

Berkun, M., Aras, E. and Nemlioglu, S., (2005.). Disposal of solid waste in Istanbul and along the Black Sea coast of Turkey, *Waste Management* 25:847–855.

BSC, 2007. Marine Litter in the Black Sea Region: A Review of the Problem. Black Sea Commission Publications 2007-1, Istanbul-Turkey, 160 page.

Carson, H.S., (2013). The incidence of plastic ingestion by fishes: from the prey's perspective. *Mar. Pollut. Bull.,* 74:170–4.

Chiappone, M., Dienes, H., Swanson, D.W., Miller, S.L. (2005). Impacts of lost fishing gear on coral reef sessile invertebrates in the Florida Keys National Marine Sanctuary, *Biol. Conserv.,* 121:221–30.

Coe, J.M., Rogers, D.E (1997). Marine debris: sources, impacts and solutions. New York: Springer

Cole, M., Lindeque, P., Halsband, C., Galloway, T.S., (2011). Microplastics as contaminants in the marine environment: a review. *Mar. Pollut. Bull.,* 62:2588–97.

Corcoran, P.L., Biesinger, M.C.,. Grifi M. (2009): Plastics and beaches: A degrading relationship. *Marine Pollution Bulletin,* 58: 80-84.

Derraik, J.G.B., (2002). The pollution of the marine environment by plastic debris:a review. *Marine Pollution Bulletin,* 44:842–52.

EPA, (2014). Environment Protection Administration Executive Yuan, Introduction to Resources Recycling (in Chinese).

Galgani, F., Fleet, D., Van Franeker, J., Katsanevakis, S., Maes, T., Mouat, J., et al. (2009). Marine strategy framework directive-task group 10 report marine litter. In: Zampoukas N,editor. Ispra: JRC Scientific andTechnicalReportsEuropean Commission Joint Research Centre.

Gaylor, M.O., Harvey, E., Hale, R.C., (2012). House crickets can accumulate poly-brominated diphenyl ethers(PBDEs) directly from polyurethane foam common in consumer products. *Chemosphere,* 86:500–5.

Gorman, M., (1993). Environmental hazards–marine pollution. Santa Barbara: ABC-CLIO Inc.

Gregory, M.R., (2009). Environmental implications of plastic debris in marine settings-entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions. Philos. Transac. R. Soc. Lond. B:Biol. Sci., 364: 2013–25.

Gregory, M.R., Ryan, P.G., (1997). Pelagic plastics and other seaborne persistent synthetic debris: a review of southern hemisphere perspectives. In: Coe J, Rogers D, editors. Marine Debris. New York:Springer, p:49–66.

Holmes, L.A., Turner, A., Thompson, R.C., (2012). Adsorption of trace metals to plastic resin pellets in the marine environment. *Environ. Pollut.,* 160:42–8.

Iñiguez, M. E, Conesa J.A and Fullana, A., (2016). Marine debris occurrence and treatment: A review, *Renewable and Sustainable Energy Reviews*, 64:394–402.

Ivanov, L.I., Backhaus, J., Ozsoy, E., Wehde, H., (2001). Convection in the Black Sea during cold winters. *Journal of Marine Systems,* 31, 65–76.

Izdar, E., Murray, J.W., (1991). Black Sea Oceanography NATO asi series c: mathematical and physical sciences (vol. 351). Kluwer Academic Publishers, The Netherlands.

Jeftic, L., Sheavly, S., Adler, E., (2009). Marine litter in the Black Sea region overview and draft strategic action plan. In: Marine Litter: A Global Challenge. UNEP Available from. https://www.unenvironment.org/resources/report/marine-litter-globalchallenge

Kuo, F.J., Huang, H.W., (2014). Strategy for mitigation of marine debris: analysis of sources and composition of marine debris in northern Taiwan. *Mar. Pollut. Bull.,* 83:70–8.

Laist, D., (1997). Impacts of marine debris:entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records, In: Coe J, Rogers D, editors. Marine Debris. NewYork: Springer, p.99–139.

Laist, D.W., (1987). Overview of the biological effects of lost and discarded plastic debris in the marine environment. *Mar. Pollut. Bull.,* 18:319–26.

Lazar, B., Gračan, R., (2011). Ingestion of marine debris by loggerhead sea turtles, Caretta caretta, in the Adriatic Sea, *Mar. Pollut. Bull.,* 62:43–7.

Lechner, A., Keckeis, H., Lumesberger-Loisl, F., Zens, B., Krusch, R., Tritthart, M., et al., (2014). The Danube so colourful: a potpourri of plastic litter outnumbers fish larvae in Europe's second largest river. *Environ. Pollut.,* 188:177–181.

Mato, Y., Isobe, T., Takada, H., Kanehiro, H., Ohtake, C., Kaminuma, T., (2001). Plastic resin pellets as a transport medium for toxic chemicals in the marine environment. *Environ. Sci. Technol,* 35:318–24.

Miladinova, S., Macias, D., Stips, A. and Garcia-Gorriz, E., (2020). Identifying distribution and accumulation patterns of floating marine debris in the Black Sea, *Marine Pollution Bulletin*, 153:110964

Moncheva, S., Stefanova, K., Krastev, A., Apostolov, A., Bat, L., Sezgin, M., Sahin, F., Timofte, F., (2016). Marine litter quantification in the black sea: a pilot assessment. *Turk. J. Fish. Aquat. Sci.,* 16 (1):213–218.

Mouat, J., Lopez Lozano, R., Bateson, H., (2010). Economic impacts of marine litter.UK: Kommunenes Internasjonale Miljøorganisasjon (KIMO International)

OSPAR, (2007). Pilot Projecton Monitoring Marine Beach Litter: Monitoring of marine litter on beaches in the OSPAR region, OSPAR Commission, London.

Oztekin, A.A., Bat, L., Gokkurt-Baki, O., 2020. Beach litter pollution in Sinop Sarikum Lagoon coast of the Southern Black Sea. *Turk. J. Fish. Aquat. Sci.,* 20:197–205.

Rochman, C.M., Hoh, E., Hentschel, B.T., Kaye, S., (2013). Long-term field measurement of sorption of organic contaminants to five types of plastic pellets: implications for plastic marine debris. *Environ. Sci. Technol.,* 47:1646–54.

Rochman, C.M., Manzano, C., Hentschel, B.T., Simonich, S.L.M., Hoh, E., (2013). Polystyrene plastic: a source and sink for polycyclic aromatic hydrocarbons in the marine environment. *Environ. Sci. Technol.,* 47: 13976–84.

Ryan, P.G., Jackson, S., (1987). The lifespan of ingested plastic particles in sea birds and their effect on digestive efficiency, *Mar. Pollut. Bull.*, 18:217–9.

Schrey, E., Vauk, G.J.M., (1987). Records of entangled gannets(Sulabassana) at Helgoland, German Bight, *Mar. Pollut. Bull.,* 18:350–2.

Simeonova, A., Chuturkova, R., (2019). Marine litter accumulation along the Bulgarian Black Sea coast: categories and predominance. *Waste Manag.,* 84:82–193.

Simeonova, A., Chuturkova, R., Yaneva, V., (2017). Seasonal dynamics of marine litter along the Bulgarian Black Sea coast. *Mar. Pollut. Bull.,* 119(1):110–118.

Sorokin, Y.S., (2002). The Black Sea: Ecology and Oceanography. Backhuys Publishers BV, Netherlands.

Suaria, G., Melinte-Dobrinescu, M.C., Ion, G., Aliani, S., (2015). First observations on the abundance and composition of floating debris in the North-western Black Sea. *Mar. Environ. Res.*, 107:45–49.

Terzi, Y. and Yahya, K., (2017). Seasonal and spatial variations of marine litter on the south-eastern Black Sea coast, *Marine Pollution Bulletin,* 120:154–158.

Teuten, E.L., Saquing, J.M., Knappe, D.R.U., Barlaz, M.A., Jonsson, S., Björn, A., et al., (2009). Transport and release of chemicals from plastics to the environment and to wildlife. Philos. Transac. R. Soc. Lond. B: Biol. Sci., 364:2027–45.

Thompson, R.C., Moore, C.J., Vom Saal, F.S., Swan, S.H., (2009). Plastics, the environment and human health: current consensus and future trends, Philos. Transac. R. Soc. Lond. B: Biol. Sci., 364: 2153–66.

Topçu, E.N., Tonay, A.M., Dede, A.A., Öztürk A.A., Öztürk B., (2013). Origin and abundance of marine litter along sandy beaches of the Turkish Western Black Sea Coast. *Marine Environmental Research*, 85:21-28.

Tuncer, G., Karakas, T., Balkas, T., Gokcay, F.C., AygÂn, S., Yurteri, C., Tuncer, G., (1998). Land-based sources of pollution along the Black Sea Coast of Turkey: concentrations and annual loads to the Black Sea. *Marine Pollution Bulletin,* 36: 409–423.

UNEP, (2005). Marine litter an analytical overview. Kenya: United Nations Environment Programme, p:47.

UNEP, (2005). Marine Litter, An Analytical Overview. Nairobi.

UNEP, (2009). Marine Litter: A Global Challenge. Nairobi, p: 232.

UNEP-CAR/RCU, (2008). Marine litter in the wider caribbean region: a regional overview. Nairobi: United Nations Environment Programme, P: 81.

URL-1, 2020. Marine Debris, https://pagev.org/deniz-atiklari, (Last Accessed: 05.11.2020).

Zeri, C., Taliadouri, V.F., Romanov, A.S., Ovsjany, E.I., Moriki, A.A., (2000). Comparative approach of dissolved trace elements exchange in two interconnected Basins, Black Sea and Aegean Sea. *Marine Pollution Bulletin*, 40:666–673.

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Protect-Streams-4-Sea Management Team
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