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ASSESSMENT OF WASTE DUMPING PRACTICES IN MOUNTAIN CREEKS

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ABSTRACT

The paper examines the exposure of mountain creeks towards illegal waste disposal practices related to the lack of waste collection services in rural areas of Romania prior to EU accession and the low waste collection efficiency following the closure of rural wild dumps in 2009-2010. The paper estimates the amounts of household waste uncollected and disposed in selected small Carpathian rivers in the North-East development region. The expansion of built-up areas along the water courses leads to waste dumping practices across mountain villages in the context of poor waste management facilities. Particular morphology of villages and hydrological characteristics of the creeks may influence the magnitude of such bad practices. The paper points out the role of flash floods in cleaning upstream catchments from debris, thus, polluting the downstream rivers and human settlements. An efficient waste collection system in mountain areas has a crucial role to play in mitigating and ultimately preventing the waste dumping practices in water bodies.

Keywords: waste dumping, water pollution, waste collection, mountain area, floods

INTRODUCTION

Poor waste management facilities cause severe pollution of water bodies in the proximity of human settlements [1]. Plastic pollution is an emerging environmental threat for marine and river ecosystems [2]. Developing and transition countries are facing serious difficulties in providing access to sound waste management services, especially in rural regions [3]. Open dumps are frequently located on riverbanks or on floodplains of rivers [4]. Mountain regions raise particular challenges in the waste management options due to the geographical barriers [5]. The lack or poor waste collection schemes in such regions lead to a high exposure of river networks as main waste dumping sites for mountain settlements. This situation still occurs in rural Romania. The paper assesses the exposure of nine small rivers from the Eastern Carpathians to illegal waste disposal practices prior and after the closure of rural dumpsites with a deadline in July 2009 according to the Government Decision Nr. 349/2005 which transposes the EU Landfill Directive 1999/31 [6].

MATERIALS AND METHODS

Nine mountain creeks of Eastern Carpathians are selected from each county of North-East region of Romania such as Putna, Suha Mare, Suha Mica (Suceava county), Calu, Iapa, Nechit (Neamt county) and Ciughes, Asau, and Casin (Bacau county). These water bodies pass throughout 24 villages being exposed to uncontrolled waste disposal practices because of the lack or poor coverage of waste collection services until the closure of rural dumpsites in 2009 followed by inefficient rural waste collection schemes. Therefore, the time scale analysis comprises ten years divided into two main intervals such as 2004-2008 characterized by the lack of waste collection services (noWCS scenario) and 2009-2013 characterized by a low collection efficiency (WCS40) with illegal dumping practices detected by field observations, mass-media and civil society. The local authority of Manastirea Casin commune from Bacau county revealed that collection efficiency was of maximum 30% of total household waste generated prior the implementation of a Phare project in October 2010 which further support the parameter WCS40 as a relevant one within the study area for the period 2009-2013.

The paper calculates the potential amount of household waste uncontrolled disposed at village level based on following equations [7]. :
$Q_{ud} = \{Q_{wu} - [(Q_{wu} - 0.7 * Q_{bw}) + (Q_{wu} - 0.1 * Q_r)]\}$
Q_{wu} = waste uncollected by formal waste management services (waste operators). This indicator is calculated according to the second equation:
$Q_{wu} = P * W_g * 365 / 1000$, P – population of the village (noWCS scenario)
W_g –per capita waste generation rate = 0.3 kg.inhab.yr^{-1} (Population Census 2002 data for time series: 2004-2008) & 0.33 kg.inhab.day^{-1}, (Population Census 2011 data, time-series 2009-2013). The per-capita waste generation rate is below the national flat rate (0.4 kg.inhab.day^{-1}) as stipulated by the National Waste Management Plan (NWMP) due to poorer socioeconomic features of the study area [8].
Q_{bw} - biodegradable fraction of household waste (62% of total household solid waste)
Q_r – recyclables (metals, paper, and cardboard, plastics, glass, wood) have a ratio of 23.5%

The data for these waste fractions are determined from the amounts of waste uncollected (Q_{wu}) using the municipal waste composition data specific for rural areas provided by the regional waste management plan [9]. Home composting and animal feed is a major diversion route from the wild dump as stipulated by Local Environmental Protection Agencies. Similar considerations are valid in Poland, where 70% of biowaste is assumed to be treated at household level via home composting, animal feed and as solid fuels for furnaces [10] while in China recovery of biowaste is over 80% [3]. Also, a part of dry recyclables may be reused, recovered or recycled at the household level (0.1).

The next stage is to calculate the amounts of waste disposed by rural localities along a riverbed or creek bank (Q_{wr}), in the proximity of built-up areas. This indicator is weighted based on the average distance of rivers/creeks to the outer limit of the built-up area. The calculations are made according to the relation [7]: Q_{wr} (t.yr^{-1}) = (Q_{ud} * - Q_{ud} *C_{ef}) *W_{dist} , Q_{wr} - waste estimated to be illegally disposed on river banks / into rivers or creeks by a locality (village).

W_{dist}= weighting factor of river dumping practice according to the average distance between the built-up area of a locality (village) and the river/creek in the proximity.

The W_{dist} has the following values [7].**:** 0.9 (1-199m), 0.8 (200-399m), 0.6 (400-599m), 0.4 (600-799m), 0.2 (800-1000m); C_{ef} – collection efficiency factor.
Such distances are measured using satellite images provided by Google Earth images taking into consideration the outer limit of the built-up area (village) towards the creek or rivers. In case the villages that are passed by other tributaries, the measuring point is performed for the closest water body. This model points out that the geographical proximity of human settlement to water bodies influences the magnitude of pollution in mountain regions within a 1 km range.

HYDROLOGICAL CONTEXT

In terms of hydrological context, the river network is drained by the principal river Siret whose drainage basin is developed mostly in the mountain area. The geological features are given by the flysch deposits (represented by clay, marl, sand, and sandstones) who generate not a very high relief (the altitude is between 200 and 1500 m), but a lot of geomorphological problems in terms of landslides and soil erosion. Most of the mountain area drained by tributaries of Siret River is quite fragmented (the average drainage density network is 1.2 km/km^2) and is affected by the human activities developed along river system in the last centuries. The rivers we analyze in this study drain the central and north-part of the Eastern Carpathians. Their drainage basins are not very developed (see table 1), but we chose to analyze them because the lack of huge hydro technical works along their valleys and because their response, which is quite natural, to any impact.

Table 1. Morphometrical data about drainage basin from Eastern Carpathian Mountains

County	River	Length (km)	Altitude (m)		Slope (‰)	Surface of the basin (km^2)	Surface covered with forest (ha)
			upstream	downstream			
Suceava	Putna	21	1480	698	37	90	7523
	Suha Mare	29	928	392	18	146	10324
	Suha Mica	26	1020	401	24	121	8222
Neamt	Calu	20	1100	266	42	62	5190
	Iapa	24	1180	264	31	75	6387
	Nechit	27	1200	246	35	106	4620
Bacau	Ciughes	15	1340	638	47	47	2367
	Casin	54	1240	199	19	308	22823
	Asau	39	1220	402	21	208	18644

In fact, the highest length of the river and drainage basin surface has Casin River with 54 km length and 308 km^2 surface. Majority of the rivers had lengths beneath 30 km and drainage basins surface no more than 120 km^2.
Most of the basins are covered with forests; the forested area varies between 23 and 41% of the entire surface of the basins. Another important parameter to analyze is the slope of the basins that varies between 18 to 47‰, an important factor in washing the debris out of the river network. An important feature of this river network is the flash-floods occurrence, the entire area being affected in the last decades. For example, only for the last decade there were at least five sequences (2004, 2005, 2008, 2010 and 2011) of catastrophic floods in the north-eastern part of Romania. The runoff values have not more than 3-6 m^3/s, but in specific meteorological circumstances, with precipitation in summer time concentrated in few hours (more than 100 mm in 4 or 5 hours), the values of the flow increase to 100 - 150 m^3/s. The causes of this kind of extraordinary flash-floods can be found in the deforestation activities, increased in the last three decades along whole Romanian mountains, and also in the climate changes impact on river networks manifested by the concentration of precipitation in summer time with a huge impact in rivers discharges [11].

RESULTS AND DISCUSSION

The selected nine creeks of Eastern Carpathians pass throughout 24 villages with 41475 inhabitants prior to EU accession and 35353 inhabitants according to the last population census (2011). There is a significant demographic decline (6122 persons) during this period explained by the emigration abroad due to the poorer socioeconomic conditions of rural communities across the North-East region. The paper estimates that 2351.298 t of household solid waste were uncontrolled disposed in the watercourses, riverbanks or floodplains of mountain creeks during a decade (2004-2013) by those 24 villages within the study area as shown in table 2.

Table 2. Estimation of household waste dumped into or near watercourses

County	Creek	Villages (nr)	Commune	Qwr_noWCS (2004-2008) (t)	Qwr _WCS40 (2009-2013) (t)	Total (t)
Suceava	Putna	2	Putna	134.299	83.956	218.255
	Suha Mare	3	Malini	141.85	81.387	223.237
	Suha Mica	3	Slatina	189.665	112.181	301.846
Neamt	Calu	2	Piatra Soimului	194.88	95.464	290.344
	Iapa	2	Piatra Soimului	121.87	54.151	176.021
	Nechit	2	Borlesti	116.343	59.314	175.657
Bacau	Ciughes	2	Palanca	111.844	66.054	177.898
	Casin	4	Manastirea Casin and Casin	217.038	126.081	343.119
	Asau	4	Asau	278.73	166.191	444.921

The susceptibility of water bodies to illegal disposal practices depends on the number of villages and their population along the watercourses, the geographic proximity of built-up areas to such water bodies. The most exposed creeks to illegal waste disposal practices are Asau, Casin and Suha Mica with over 300 t of household waste.

Villages dumped over 100 t of wastes in each mountain creek of study area due the lack or rudimentary of waste collection services prior the closure of rural dumpsites in July 2009. The presence of waste collection services reduce the amounts of waste disposed in water bodies even at a low collection efficiency (844.83 t) compared with worse case situation from the previous period (1506.63 t). In fact, limited waste collection services were available in rural municipalities across all regions of Suceava, Bacau, and Neamt counties prior to EU accession, which highly exposed the water bodies from all geographical regions (mountain, subcarpathian, plateau, corridor valley) to severe pollution threats. The EU funds help some rural communities to provide the first source separate waste collection facilities. The communes of Casin and Manastirea Casin have implemented a Phare project to introduce a separate collection scheme for residual waste, glass, plastics, paper/cardboard waste fractions. The project has been finished during 2007-2010 and the inter-municipal cooperation created a public waste operator. Waste platforms each containing 4 containers (1100l) are located throughout the villages and two garbage trucks will transport the wastes towards urban landfills.

A similar project includes Piatra Soimului and Borlesti communes (Neamt county) where collection platforms are available for plastics, biowaste, paper/cardboard and residual waste. This collection system is operational since 2011 and the wastes are transported to the transfer station of Roznov city. However, field observations point out that Calu, Iapa, and Nechit mountain creeks are still exposed to illegal waste dumping practices. The master plan concerning the Integrated Waste Management System in Neamt County project, supervised by Neamt County Council, has no record of rural dumpsites for Borlesti commune despite critical waste dumping practices were detected during field observations (figure 1). The same document reveals the presence of a rural dumpsite in Piatra Soimului, but on Bistrita riverbank [12].

Neither data of National Environmental Guard (County Commissariat of Neamt) do not reveal the presence of illegal dumping sites across Calu, Iapa or Nechit creeks. In case of Bacau county, there is one dumpsite in Casin village (0.025 ha, volume of 500 m^3), but there is no data for Palanca (Ciunghes creek) or Asau communes. In this context, the official statistics are irrelevant in the assessment process of river dumping practices. All three communes of Suceava county reported at least a rural dumpsite on their territory such as Malini (1 ha, volume of 10000 m^3), Putna (0.285 ha, volume of 4725 m^3), Slatina (0.15 ha, volume of 1000 m^3). The above data suggest that all communes within the study area are dealing with illegal disposal practices mainly in the first stage (2004-2008), but without concrete data about the presence of such dumpsites along watercourses despite the evidence revealed by field observations. Furthermore, themed controls regarding the sanitation status of water bodies are still carried out suggesting that illegal dumping practices issues are far from being eliminated.

As an example, the following watercourses were verified in the spring season (2018) by a mixed team (Prefecture, County Water Management System, National Environmental Guard-County Commissariat, Inspectorate of Emergency Situations): Suceava, Siret, Moldovita, Moldova, Bistrita, Dorna, Putna, Suha Mare, Suha Mica.

Figure 1. Waste dumping practices on mountain creeks (Eastern Carpathians)

This control was intended to highlight [13] (i) the existence of wild dumpsites and wood wastes on riverbanks and in the watercourses, (ii) the presence of such wastes near of bridges which by training may lead to obstruction of leakage; (iii) the existence of wood waste accumulation in torrential formations near inhabited areas (iv) how the maintenance of pluvial drainage is made across the localities, and (v) to inspect watercourses and to monitor local measures addressing deficiencies.

Such controls are performed in each county under the supervision of environmental authorities, particularly in the spring season (April-May). New local sustainable development strategies point out the emerging necessity of sound waste management services across rural communities. As an example, the Asau commune aims to cover until 2022 following basic utilities [14]: (i) 80% of the population to be connected to water pipelines (ii) 70% of the population should have access to an integrated waste management system, (iii) 65 % of the population should have access to improved sanitation facilities.

Poor waste management facilities and sanitation facilities are critical pollution sources for surface waters and groundwater across rural communities threatening the public health. North-East Region is facing major challenges in this area because of the lack of investments in such key sectors supported by the ignorance of central and local authorities. Mountain rivers and creeks are most susceptible to illegal waste disposal practices due to the geographical restrictions imposed by the Carpathian Mountains.

The critical period of rural waste dumping practices (2004-2008) has been overlapping with the floods which had affected the creeks and villages of the study area in 2004, 2005 and 2008. Most of the wastes dumped into watercourses and floodplains prior the closure of rural dumpsites in July 2009 might have been washed up in downstream rivers. This situation explains the poor coverage of rural dumpsites statistics in terms of surface and volumes, particularly in the communes of the mountain region [7]. During the floods, the main rivers collect the floating wastes from upstream tributaries such as Moldova (Suha Mare, Suha Mica), Bistrita (Calu, Iapa, Nechit) or Trotus (Ciunghes, Asau, Casin). The second stage (2009-2013) is characterized by basic waste collection services plus illegal waste disposal practices. The floods of 2010 and 2011 have cleaned the mountain creeks from wastes illegally disposed in the second stage. The mixture of household and wood wastes contributes to the higher destructive force of floods in downstream localities increasing the risk of material losses or threatening the life of the inhabitants and their livestock. Mixed fractions of household waste contain hazardous items (batteries, oils, electronic waste, paints etc) which may release toxins into water bodies. Rural dumps are often mixed with sawdust in mountain area which increases the toxic potential of river ecosystems. Despite recent improvements of waste management infrastructure the inhabitants, economic agents must be more responsible regarding the proper waste collection activities otherwise the river dumping practice will continue to threaten the mountain creeks.

CONCLUSION

The paper estimates that 2351.298 t of household solid waste were uncontrolled disposed in the watercourses, riverbanks or floodplains of mountain creeks during a decade (2004-2013) by 24 villages within the study area. The lack of waste collection services during 2004-2008 of surrounding villages led to the disposal of over 100 t of household waste along each watercourse varying from 217 t (Asau creek) to 111 t (Ciunghes creek) with an average of 167.391 t. The closure of rural dumpsites in 2009 obliged local authorities to provide basic services for the collection of household waste. The poor collection efficiency during 2009-2013 is supported by field observations where several waste dumping practices are detected within the study area. The model estimates 844.83 t of rural household waste uncontrolled disposed with an average of 93.87 t in the second stage. Both periods were characterized by major floods which transport a part of wastes into downstream rivers (Moldova, Bistrita, Trotus) which might finally end into the Siret river (e.g. plastics). The mountain creeks are significant contributors to the pollution of rivers during the major floods collecting the wastes disposed across all catchment areas. The environmental authorities should better monitor the illegal dumping practices with relevant data in this regard. The improvement of waste collection schemes across rural mountain localities should be an emerging priority at local and regional levels in order to seriously mitigate the magnitude of river dumping practices across Eastern Carpathians.

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