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ABSTRACT

The paper examines the per capita waste generation rates from rural areas of Neamț County (Romania) using thematic cartography. Geographical approach of this issue is difficult because the lack of a geostatistic database at commune scale. Spatial analysis of waste indicators reveals several disparities between localities. Comparability of data between communes located in various geographical conditions must be carefully made according to local waste management systems. Several dysfunctionalities are outlined in order to compare these results, on the one hand, between localities and on the other hand, between recent years. Geographical analysis of waste generation rates is imperative for a proper monitoring of this sector. Data from 2009, 2010 and 2012 shows that rural waste management is in a full process of change towards a more organized, stable and efficient system.

Keywords: waste generation, rural areas, local disparities, geography of waste

INTRODUCTION

Per capita waste generation is a key indicator in the analysis of waste management [1], [2], but it is difficult to calculate for rural areas due to the lack of an adequate statistical database. Evidence of these wastes sometimes occurs in statistical questionnaires of waste operators which have extended their activity from cities to surrounding rural settlements but the data are not broken down at commune level. In such cases, only waste generation rates for a group of communes can be determined and a geographical differentiation is not possible. However, regional studies on waste management issues include urban and rural areas [3- 5]. Rural regions are often exposed to bad practices in waste management sector and more papers should focus on these areas [6], [7]. Poor waste management facilities and low coverage of waste collection services (WCS) from rural Neamț county contribute to illegal dumping. Several quantitative assessment methods of illegal dumping are proposed according to regional and local geographical conditions from rural areas [8 - 11] and on the other hand, GIS techniques are used in order to determine such areas susceptible to illegal dumping [12]. In this context, spatial analysis of waste indicators at administrative territorial units scale of rural Romania is just at the beginning [13],[14]. Geography of waste has an opportunity to play an important role on this matter [15].

METHODS

The regional and local waste management plans stipulate an average waste generation rate (I_g) of 0.4 kg. inhab. / day in rural areas. Per capita waste generation is calculated as follows: I_g (kg / inhabitant / day) = $Q_{hw} / P_s / 365$, where: Q_{hw} - the amounts of household waste collected from population at commune level, P_s - population served by waste collection services (WCS). Spatial analysis of rural waste generation rates at commune scale is performed for 2010 and 2012. The quality of data on waste generation rate are also influenced by several local factors as follows:

- No everyone have signed individual contracts in rural localities with waste operators
- There is no clear evidence of waste operators regarding the number of population served / total population
- Commonly, there is a share of population which do not pay / contract a permanent waste collection service
- estimation of quantities is performed taking into account the volume of containers or vehicles or the volume specified in the contracts, landfills (where these wastes are disposed) do not have weighing devices, thus, quantities are not reliable being frequently overestimated.
- only a part of wastes generated are collected (depending on the efficiency of waste collection) the rest being uncontrolled disposed by waste dumping or burning
- individual contracts concluded with residents of a commune are fluctuating from month to month, in case of delegated services, it takes into consideration the entire population as served although only a segment actually collects the wastes (thus reducing the actual waste generation rate)
- there are individuals and / or households who do not pay the fees for sanitation services received, in these cases, rural administrations provide so-called cleaning campaigns in spring and autumn freely but with higher costs for local budget.
- is not known exactly the stable population of a commune due to labour migration, major differences are reported comparing data between National Institute of Statistics and Population Census (NIS_2010 & PC_2011 - partial results).
- is not known exactly the ratio of waste collected from households and those from businesses and local institutions (similar fraction), in such cases, the total per capita generation rate of the population may be overestimated
- This calculation applies to wastes from household sources but frequently in collection points (bins) are also disposed fractions of agricultural origin (branches, wastes from gardens).

This indicator couldn't be calculated during 2003-2006 due to lack of necessary data but in 2007, first per capita waste generation rate was calculated (0.46 kg /capita /day) for Cordon & Trifești communes, served by the same operator *SC Rossal SA*. Later in 2008, this indicator (calculated for all rural areas served by *SC Rossal Roman SA*) increased to 0.802 kg/person/day (Trifești, Cordon, Sagna, Gherăești and Hălăucești which is part of Iași county) being close to values of urban areas, in 2009, this rate dropped to 0.74

kg/person/day (Trifești, Cordon, Gădintți, Sagna, Gherăești, Săbăoani communes), average of rural territory being 0.67 kg./inhab/day in the period 2007 - 2009.

These annual fluctuations are primarily due to annual changes in coverage areas of waste collection services, quality of data varies from one place to another with direct implications on the overall waste generation rate for rural territory. This is also highlighted for other waste operators such as *Romprest SA* - 0,9 kg / inhab/ day in 2008 (covering Alexandru Cel Bun, Gârcina, Pângărați, Săvinești & Dumbrava Roșie communes) approximately 15.8% of the population being served (4789 inhabitants) in 2009. The waste generation rate was only 0.23 kg./person/day for the same area and number of population served. These differences derive from scarcity of major annual data of waste operators records, on the other side, data from statistical surveys reported to EPA Neamț are broken only for urban / rural environments and not at the city and commune scale, thus hindering a relevant territorial analysis. Also, per capita waste generation rates may be just as unreliable in case of waste operators which serve only a commune because there is not a clear evidence of how many people actually are connected to waste collection services. In such cases, the amount of the waste collected is divided by total population, thus reducing the real value of waste generation rate such as: Poiana Teiului (0,083 kg/inhab./day_2009), Girov (0,16 kg/inhab/day 2008), Pângărați (0,14 kg/inhab./day _2009) and in some cases these values are overestimated (initial volumetric estimations then converted to units of mass using a specific density of waste 350 kg / m³) as in the case of Farcașa commune (1,002 kg/inhab./day_2009).

RESULTS AND DISCUSSION

Extension of waste collection services is significant since 2009 (when local dumpsites had to be closed until July 16) following local authorities to set up their own services or to delegate them to private operators. More reliable results were calculated for the following communes: Vânători Neamț (0,312 kg/inhab./day_2008), for 2009: Grințies (0,43 kg/inhab.day), Bodești (0,45 kg/inhab./day), Ștefan cel Mare (0,39 kg/inhab./day), Războieni (0,47 kg/inhab./day), Săvinești (0,33 kg/inhab./ day), Săbăoani (0,63 kg/inhab./day). Moreover, it achieved a monthly changes of waste generation rates for some of them (depending on data availability) shown in Figure 1.

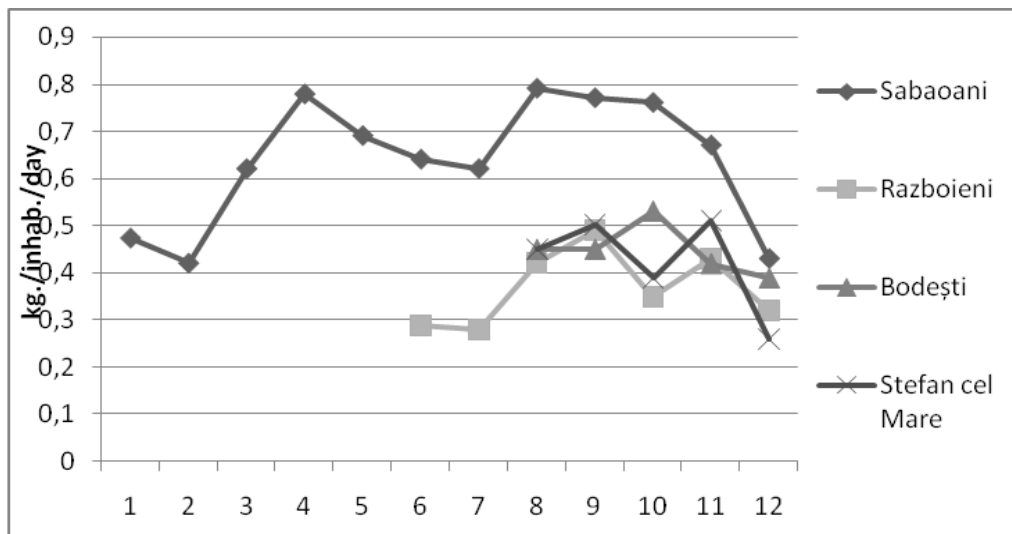


Fig.1 Monthly variation of per capita waste generation in 2009

Thus, one can observe a growing trend of household waste in the warm season with a maximum overlapped July-September (Sabaoani, Războieni) followed by a significant decrease in the cold season with a minimum in the months of December-January for most communes. Fluctuations in the warm season is due to the quality of reported data for communes where waste collection services are just implemented. Monthly variation reflects increased consumption of biodegradable products as well as recyclables (eg PET bottles, paper, cardboard) in the warm season. However, there are obvious disparities between the gap of waste generation rate for Săbăoani commune such as 0.4-0.8 kg / capita / day (located on the terrace of Moldova river, highest density in the county with a population of over 10,000 inhabitants) compared to other communes in Carpathian region with a gap between 0.28 to 0.49 kg / capita / day. These results are also a consequence of socio-economic differentiation in the county. As regards the source of waste collected, the share of similar waste (SW) from businesses and institutions of all household waste (population) and similar (HSW) ranges from 2-5% (Dragomirești, Gădiniți) to 30% (Brusturi, Drăgănești), exceptional value of Grințieș commune (over 50%) is not credible, the data reported by local authorities being overstated and questionable. Also, these significant variations from one place to another is due to the quality of data submitted by each waste operator and also depends on fluctuations in the number of economic operators that have contracts with these operators.

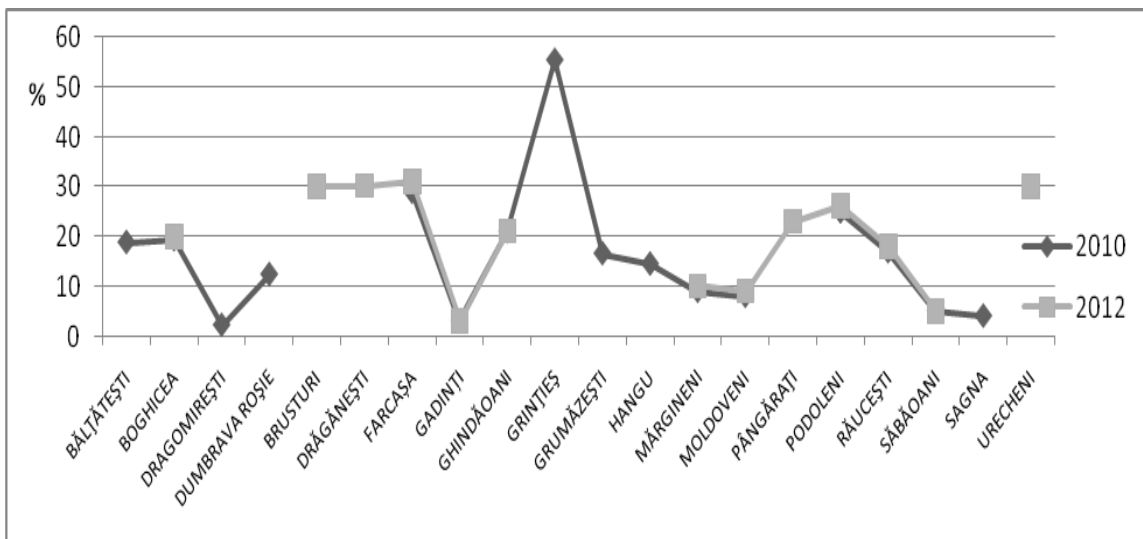


Fig.2 Share of similar waste from all waste collected in 2010 and 2012

Referring to Figure 2, it is noted there are no significant variations in the share of similar waste between 2010 and 2012. Waste generation indicator cannot be calculated for all the communes (covered by waste collection services) and on the other hand, such values are difficult to interpret due to:

- ✓ lack of evidence of wastes collected (eg Dochia & Negrești communes)
- ✓ required information were not provided by local municipalities or by waste operators
- ✓ data provided concerning the amounts of waste collected are an overall average (often purely theoretical which do not reflect the field situation): Grințieș, Dumbrava Roșie, Oniceni, Crăcăoani, Girov, Grumăzești, Ion Creangă

- ✓ total waste collected are transmitted, there are no disaggregated data for population and economic agents, thus, influencing per capita waste generation rate (Alexandru cel Bun, Bahna).

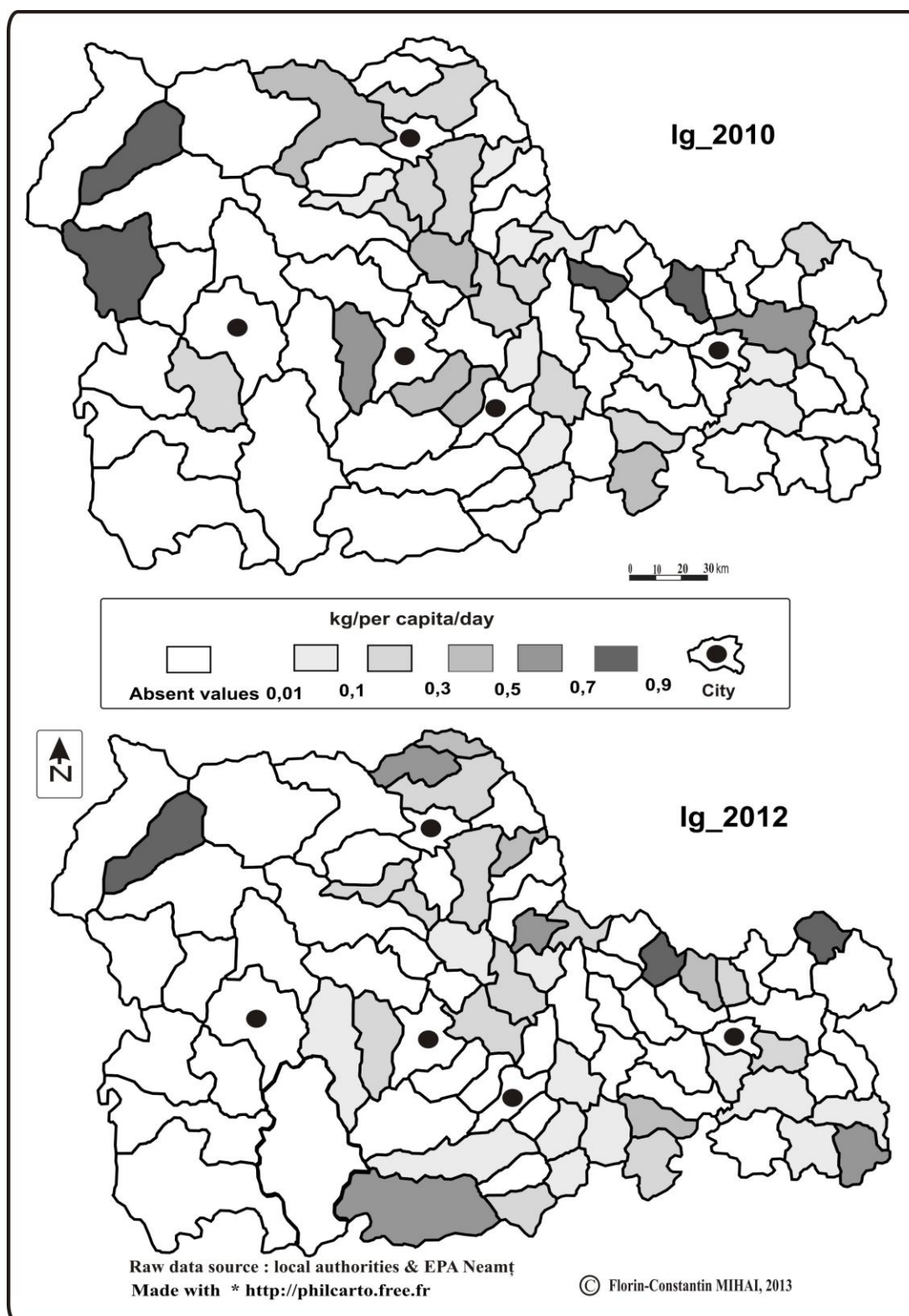


Fig. 3 Spatial distribution of per capita waste generation rates

Very low rates of per capita waste generation (0.01-0.1 kg /inhab./day) for 2010 to 2012 shows that either there is no credible evidence of waste streams or waste collection system is not effective, these values are too low compared to the average value of this indicator such as 0.35/ 0.4 kg/inhab./day stipulated in local waste management plans. Equipping the waste collection, recycling and disposal centers with weighing facilities is imperative for a proper monitoring of waste indicators. Therefore, the analysis for 2010 noted some major differences between suburban communes of Piatra Neamț and Roman cities, which had high rates or close to the overall average (> 0.3 kg.inhab/day) and most communes with low rates or very low (0.01 to 0.3 kg / person / day). The high values up to 0.7 kg/capita/day (comparable to those from urban areas) are specific to the peri-urban communes or densely populated areas connected to waste collection services (Alexandru cel Bun, Săbăoani, Gherăești,) yet, these values are overestimated due to volumetric estimations particularly in the case of remotest communes to urban centers (such as Farcașa, Grințieș & Văleni in 2010, Boghicea in 2012). The annual differences of these indicators depend by fluctuations of population served (which have contract with a waste operator) and secondly, by fluctuations of stable population between NIS records in 2010 and Population Census_2011 (preliminary) for 2012. For example, acceptable annual variations were observed in case of Săbăoani (the most populated commune in the county), namely: an increase to 0.63 kg/ inhab. / day in 2009 to 0.73 kg /inhab./ day 2010, followed by a decrease to 0.47 kg /inhab. /day, becoming a *witness indicator* (reliable) as compared with other communes in the county. On the other hand, some differences are major by significant increases in waste generation rates (in a short time) between 2010 and 2012 in case of Războieni (0,094 _0 577 kg./inhab./day), Boghicea (0,128 _0, 828 kg.inhab./day) or even decreases in the case Alexandru cel Bun commune (0.507 _0 195 kg/ inhab /day).

CONCLUSIONS

These oscillations suggests that the rural waste management is in a full process of changes towards an organized, stable and efficient system. In this context, geographical analysis of waste indicators is only at the beginning but it becomes increasingly necessary for a meaningful assessment of environmental policies from EU to local scale. Lack of necessary data for all communes covered by waste management services and questionable quality of available ones do not allow to outline certain spatial patterns related to various socio-economic and geo-demographic factors. Per capita waste generation implications are complex and disparities which exist locally, regionally and nationally can be explained only through a database broken down to the ATU's level based on weighted values in the detriment of volumetric estimations.

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