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Solid Wastes Wastewater and Remediation Costs in An Urban Slum: The Case Study of A Gypsy Camp in Napoli (S Italy)

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Abstract

Slums represent a sort of black box within the urban environment, generating multiple impacts, that are often acknowledged, but forgotten by urban planners and policy-makers when envisioning the future of cities, due to the dimension of social exclusion in which slum dwellers live. These criticalities pose a further threat to urban sustainability. The first problem is revealed by the lack of quantifications about many environmental and socio-economic factors, as well as by a general lack of understanding about slums as systems. This study is aimed at overcoming the present knowledge weakness, developing a preliminary site-specific system representation of a slum as a system. In particular, a case study of a Gypsy camp in Napoli (S Italy) was chosen for such a purpose. Focusing on solid waste, an approximate evaluation of informal waste picking activity was performed. Basic parameters of generated wastewater, which is dispersed in the environment due to the absence of any sewerage infrastructure, are accounted according to environmental engineering standards. In addition, considering a second abandoned camp (Brecce Sant'Erasmo, Napoli, Italy), specific-site remediation costs were calculated. Results evidence the necessity of a better understanding of resources flows within slums. A first planning action for the studied area would be to separate the areas for waste processing with respect to living areas. Basic infrastructures for solid waste and wastewater management are also necessary to improve the life quality of slum dwellers, while reducing the existing impacts. Finally, also a study to detail atmospheric emissions characteristics would be desirable. Specific upgrading solutions are indicated on the basis of the existing literature. They include planning and monitoring actions, together with the development of engineered solutions for waste and wastewater management.

1 Introduction

Since the inception of villages, towns and cities, mankind has striven to produce livable towns and cities and organize them according to their specific sociocultural, political-economic characteristics and environmental constraints. Whether cities are only 'parasites', whose survival depends on the appropriation of external resources,

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still remains an open question (Liu et al., 2016). In fact, cities' dependence on non-local and prevalently non-renewable resources is a major driver of urban environmental unsustainability (Zucaro et al., 2015). In parallel, other environmental problems exist. Besides the emission of a huge amount of pollutants, which impact on the air, soils and water, the global production of Municipal Solid Waste (MSW) in year 2012 reached 1.3 billion metric tons, according to Hoornweg and Bhada-Tata (2012). Moreover, data show that 330 km^3 of municipal wastewater are generated yearly in the world (Mateo-Sagasta et al., 2015). Finally, the growth of urban areas and population, which is expected to reach 5 billion in 2050, is generating several social challenges, among which the reduction of poverty and the decline of unemployment rates are especially relevant (Zhang, 2016).

Representing a case of evident socio-economic inequality and environmental degradation within cities, slums are considered special areas within urban systems. UN-HABITAT defines a slum household as a group of individuals, living under the same roof in an urban area, who lack one or more of the following: Durable housing of a permanent nature that protects against extreme climate conditions; Sufficient living space, which means not more than three people sharing the same room; Easy access to safe water in sufficient amounts at an affordable price; Access to adequate sanitation in the form of private or public latrines shared by a reasonable number of people; Security of tenure that prevents forced evictions. The main characteristic of slums, according to UN-HABITAT (2012a), is the "level of perpetual poverty, deprivation and socio-spatial exclusion to which the people residing in them are subjected to live in, a condition that also affects the overall prosperity of the cities and towns in which they exist". Despite some gains due to developed actions, according to United Nations, presently 833 million people live in slums, representing about 24% of the global urban population (source: www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-11.pdf). Among them, the special case of nomadic Gypsies should be considered. A number between 120,000 and 150,000 Gypsies live in Italy, out of which about one third (i.e.: 40,000-50,000) lives in isolated and poorly served camps (Brunello, 1996; ERRC, 2000; Monasta, 2004). Both cultural identity and nomadic nature of Gypsy population make the nature of their settlements intrinsically temporary and comparable to other slums in the world, becoming a case of specific interest (Kabachnik, 2009; Sigona, 2011; Kabachnik, 2012).

The idea of slum upgrading derived from the Rabat conference, where the slogan "Making slums history" was coined (UN-HABITAT, 2012b). In particular, it consists of physical, infrastructure, social, economic, organizational and environmental improvements, which stem from an appropriate assessment of each factor related to slum life conditions. More in detail, slum-upgrading process should include the following steps (Olthuis et al., 2015): Define the locational attributes of slums; Define a method to study slums and their impacts; Use the most updated available databases; Concentrate also on legality issues. The attributes of slums and their dwellers were studied in past researcher, which mainly concentrated on social and health factors (e.g.: Aboderin et al., 2017; Castells-Quintana, 2017; Corburn and Sverdlik, 2017; Ezeh et al., 2017; Lilford et al., 2017; Mberu et al., 2017; Pater and Gleason, 2018). Environmental analyses were often neglected, with the exception of some recent papers (e.g.: Joseph et al., 2014; Duque et al., 2015; Katukiza et al., 2015; Kohli et al., 2016; Kovacic and Giampietro, 2017; Teferi and Newman, 2017). Existing studies generally refer to specific case studies, from which further extrapolations and generalization would be difficult, with the exception of remote sensing techniques applied to land use characterization. Major focuses of past investigations were: health impacts of slum dwellers lifestyle; approach to slum site characterization through remote sensing and GIS representation; definition of site-specific metabolic patterns; informal economy; water and sanitation, mainly in connection to health impacts. Deeper studies on environmental impacts, as well as on solid waste and wastewater generation are presently missing.

The Millennium Development Goals report (MDG, 2000) pointed out the need of upgrading urban life, considering also improved waste management and sanitation services. Sustainable Development Goals implemented the previously fixed targets. Some of them are especially relevant to slums (SDG, 2015):

- Goal 6: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations; By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally;

- Goal 11: By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums; By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management;
- Goal 12: By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse (Goal 12).

Besides these principles, not much has been done to change the present social, economic and environmental conditions of life in slums. The first problem in facing a search for solutions, is the lack of accurate data collection and analysis, due to intrinsic difficulties in developing appropriate field surveys, as well as due to poor data quality (Lucci et al., 2018). This problem is relevant, considering the fact that waste picking is a major activity for slums dwellers. Coffey and Coad (2010) listed some problems related to waste picking: (1) Waste dumping in unsuitable or unwanted places; (2) Wrong waste recycling process, which lead to serious air and water pollution episodes; (3) Waste scattering along streets and open spaces; (4) Potential health risks, derived from unprotected or insufficiently protected waste picking operations in disposal sited by informal waste pickers; (5) Potential health risks, related to waste abandonment, both for informal waste pickers and the general public. Instead, the design of storage and collection systems should take local attitudes and beliefs into consideration to avoid the failure of waste management processes (UN-HABITAT, 2011). In parallel, a research recorded that, in year 2015, 2.4 billion people still didn't had access to any sanitation facility, generating different context-specific impacts (Hutton and Chase, 2016).

Some research questions arise from these premises: (1) How to represent a Gypsy camp as a system? (2) How to perform a qualitative assessment of waste and wastewater generation within an informal urban settlement in the case of lack of data? (3) Which are the known costs for managing a Gypsy camp, as well as the economic costs related to remediation for a Gypsy camp, being temporary settlements by nature? Two areas are considered for this study: an existing Gypsy camp in Scampia (Napoli, S Italy) and an abandoned camp in Brecce Sant'Erasmo (Napoli, S Italy). This paper is structured as follows. The first section introduces the case study, defines the method used for our investigation, together with the introduced hypotheses and their relative limitations. In the next session, the Scampia camp is represented through a dynamic system, combined with a preliminary inventory of resources and processes involving the camp as a system. Waste scavenging is, then, investigated as a first environmental-related parameter. Wastewater characteristics are defined according to environmental engineering standard principles, which are aimed at determining potential characteristics of necessary infrastructures, which are presently missing. A sub-section, then, discusses about the known management costs applied to Scampia camp and the potential remediation costs, referred to Brecce Sant'Erasmo abandoned area. The discussion is focused on public policies and actions for slum upgrade, together with desirable monitoring activities. Further considerations are, then, developed with respect to waste scavenging and to wastewater generation and management.

2 Instruments and methods

2.1 Study sites

Our case study considers two Gypsy camps located in Napoli (Southern Italy). The first one is located in the area of Scampia, in the Northern part of Napoli municipality (Southern Italy). This first case is chosen to give an approximate account on waste and wastewater generation within an informal urban settlement. Moreover, it is also possible to give an esteem of costs payed by Napoli municipality to maintain the camp. In parallel, another Gypsy camp, located in the area of Brecce di Sant'Erasmo (Southern Napoli) is chosen as reference to discuss

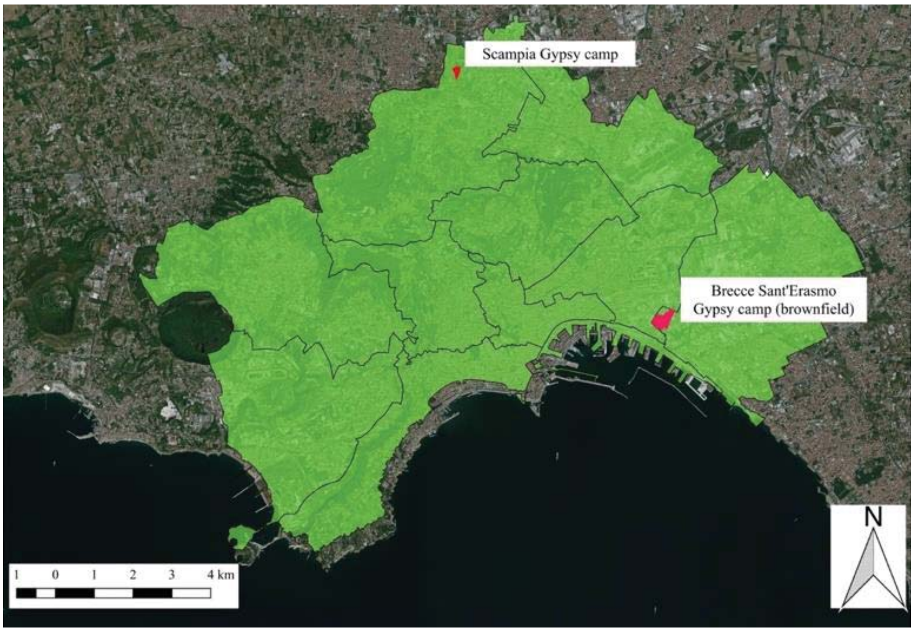

Fig. 1 Location of the two Gypsy camps in Napoli (Southern Italy). The two areas are identified with red layers within the municipality of Napoli (green layer). In particular, the upper one refers to Scampia camp, while the lower one to the abandoned camp in Brecce di Sant'Erasmo.

potential remediation costs. The second camp, which abandoned at the end of 2017, will require a remediation. The second site has been chosen also because the size of this brownfield is known (8.2034 ha). The remediation costs, mainly depending on the lack of infrastructures and on the unknown environmental impacts depending on the camp inhabitants' lifestyle, parallels the costs for camps maintenance, which were accounted for the first camp, since they are payed by the same municipality. No previous papers, up to our knowledge, previously treated the same topics in the literature.

The two areas are identified with red layers within the municipality of Napoli (green layer) in Figure 1. In particular, the Northern one refers to Scampia camp, while the Southern one to the abandoned camp in Brecce di Sant'Erasmo.

Figure 2 reports two pictures of Scampia Gypsy camp. On the left, a view of the camp is given, where the temporary nature of the settlement, typically composed by self-made shacks made of scrap materials, is also revealed by the picture. The use of such materials, collected through waste scavenging is characteristic of Italian nomad camps (Monasta et al., 2008; Fioretti, 2011).

Population data, as well as main economic costs for supporting the life of the settlement, are derived from the only available report on Gypsy camps in Italy, published in year 2013 (BCLO, 2013). Even if these settlements should be temporary by nature, they tend to become definitive in the case of Italian nomad camps, as observed by Rahola (2003).

The available data for the Scampia Gypsy camp is: population data; input materials (mainly derived from informal waste picking); water consumption (cubic meters). In particular, water consumption is derived from the costs of these items, as reported by BCLO (2013), multiplied by the mean unit costs (i.e.: /liter of water) paid in the same area (i.e.: Napoli), as indicated by the Italian National Institute of Statistics (ISTAT). Partially accountable outputs are waste and waste (sludge) water production.

Fig. 2 Pictures of Scampia Gypsy camp. On the left, the general view of the camp is given. On the right: waste abandonment in the area surrounding the camp.

2.2 System representation of a Gypsy cam

The structure of biophysical and economic flows of Scampia Gypsy camp is approached through a preliminary inventory and a diagram representing resources, their stocks, flows, processes and forcing external factors, considering the Gypsy camp as a system. A preliminary table is compiled for such a purpose. In parallel, a graphical representation of the system is developed, based on the approach of H.T. Odum and followers (e.g.: Odum, 1996; Odum and Odum, 2000; Brown, 2004).

2.3 Slum population

With respect to the population of the Scampia camp (Napoli, Italy), the report by BLCO (2013), based on the only existing field data collection, indicates that 700 people live there. Considering the approximate number of Gypsies living in camps in Italy, Scampia camp population represents about 1.5% of the total. Thus, it can be considered a small settlement. However, this is one of the rare cases in which some details were analyzed by previous studies. The access to work for this population is affected by strong discrimination all over Italy, as reported by Sigona and Monasta (2006). This is why, in this case, their economy is mainly informal. In particular, waste picking is the main activity performed by people living in camps. In parallel, as shown by Basso (2016), only 18% of the Italian Gypsy population (i.e.: between 21,600 and 27,000 people) have a regular work.

In order to make an approximate yearly estimate of waste picked by people living in a Gypsy camp, we have to make some other preliminary assumptions. First, a report discussed in the Italian Senate contains an estimate about the population under 18 years of age, which constitutes about 60% of the Gypsy population in Italy (Senato della Repubblica, 2011). The same report indicates that 46% of the total population is between 14 and 18 years. This is an age where, according to the existing survey, the camp inhabitants are already involved in informal working activities. On the other side, another study indicates that only 2.8% of the population is above 60 years (Basso, 2016). This means that about 20% of the total camp population might be working in the 'informal' waste-picking activity. This conservative estimate might be improved through field studies, which are currently missing.

2.4 Municipal solid waste informal collection and wastewater flow parameters calculation

Waste picking is used both as an informal economic activity (through waste separation and reselling of materials, such as metals, plastics, and so on) and as a way to recovery specific materials, which can be used either as scrap materials for construction or for the needs of slum dwellers. The estimate of informally-picked waste, derived from scavenging of municipal solid waste, refers to 140 people of the Scampia Gypsy camp (the remaining working force, if excluding people above 60, under 14 and formally working). The amount of collected waste is accounted on the basis of individual mean values given by Wilson et al. (2012). In particular, two facts are relevant: direct field observation indicate that waste picking is performed by walking people, without any use of any transportation mean, supported by self-made trolleys; the amount of individually collected waste varies between 50 kg and 110 kg, as reported by UN-HABITAT (2010) and Linzner and Lange (2013). It is important to remark that Gypsies operate as autonomous or unorganized dump/landfill waste pickers, as well as street waste pickers, according to the definitions of the WIEGO (online: www.wiego.org/informal-economy/basic-categories-waste-pickers). The amount of daily collected waste is obtained multiplying the daily collecting capacity (from 50 kg to 110 kg) by the number of waste pickers (140 people). Then, the year amount is obtained from daily one. Then, the year amount is obtained from daily one, considering that this working activity is performed all the days of the year (Basso, 2016).

Data on produced waste are not available and cannot be deduced from previous investigations on municipal solid waste (MSW) for the metropolitan area of Napoli, which were reported in a study of Ripa et al. (2017). In fact, it is known that MSW production varies as a function of economic well-being and population density (Kawai and Tasaki, 2016). However, the study of Ripa et al. (2017) can serve as a reference to understand the mass percentage of collected waste with respect to the MSW produced by the municipality of Napoli, whose population is 983.755 inhabitants. Given that, for the metropolitan area of Napoli, counting with 3.055.339 inhabitants, the amount of collected waste is 1.46×10^9kg/year (equivalent to 4.78×10^2 kg/year per capita of MSW), the year production for the municipality of Napoli is 4.70×10^8kg/year. The fraction interval, expressed as mass percentage, of informally-collected MSW, is calculated dividing the informally-collected MSW mass with respect to the total mass of MSW produced yearly in the municipality of Napoli.

Consumed water amounts is derived from year water costs, from 2005 to 2011, paid by Napoli municipality (BCLO, 2013). This cost is 219,919.67 €. Per capita water consumption (L_{pcd}) is accounted, on the basis of the residing population (i.e.: 700 inhabitants) and considering that official data report 59% of water losses with respect to the nominal value for the Campania Region, where Napoli is found Region (Viceconte, 2006). Consequently, the individual water consumption, which should be considered, is only 41% of the water volume derived from cost-water volume conversion. Wastewater parameters, being an assessed practice in hydraulic engineering, are derived from the value of water demand. Average sewage flow standard calculation is performed according to the following the equation (Von Sperling, 2007), used as universal reference for wastewater flows calculation in environmental engineering:

$$Q = \frac{\text{Pop} \cdot L_{\text{pcd}} \cdot R}{1000} [\text{m}^3/\text{day}] \quad (1)$$

where Q is the sewage flow; Pop is the population (here, 700 inhabitants); L_{pcd} is the per capita water consumption (expressed in m^3/day), whose calculation includes the dispersions of water distribution system; R is return coefficient (fixed to 0.8). Biological Oxygen Demand (BOD) and Total Suspended Solid (TSS) are indirectly esteemed, based on the standard method, originally defined by Metcalf and Eddy (2003). In particular, since no field measure is available, typical Italian average BOD (54.5 g/capita day) and TSS (63.5 g/capita day) values are taken (Metcalf and Eddy, 2004) and multiplied by Q. The obtained values can be applied to this case for designing a new water treatment system.

2.5 Economic costs evaluation

Available economic costs are directly reported from BCLO (2013). In particular, monetary costs are actualized to year 2017 using the official Italian Statistical Institute (ISTAT) online calculator[a]. In particular, costs, actualized for year 2013 in BLCO (2013), are multiplied by a fixed factor, referred to year 2017, as defined by ISTAT.

The cost for site remediation, applied to the camp of Brecce di Sant'Erasmo, which was abandoned in April 2017, are derived from a report (EP-NRA, 2008). A brownfield is defined as complex, if at least three main conditions exist: services may need to be cut off at the site boundary or from below ground (e.g.: illegal

[a] www.istat.it/it/prodotti/contenuti-interattivi/calcolatori/calcolo-delle-rivalutazioni

electricity and water connections); demolitions could be complex and risk of contamination might be present; hazardous materials and contaminants might be encountered. These conditions exactly reflect the ones generally existing in Gypsy camps. Depending on the foreseen end use, remediation costs are variable. Thus, a value range is determined (minimum and maximum costs) as a function of foreseen end-use.

3 Results and discussion

3.1 Results

3.1.1 Gypsy camp system representation

Fig. 3 reports a diagram dynamic representation of the Gypsy camp located in Scampia, developed according to the inventory reported in Table 1.

On the left side, the energy flows generated by natural resources (i.e.: Sun, wind, rain) are the natural input to the system. Above, other inputs are considered: water from public water distribution system; fuels, used by the slum dwellers for heating, cooking, as well as for transport (e.g.: cars); electricity, whose expenses are presently sustained by the Municipality of Napoli, as in the case of public water; solid waste materials collected through waste picking; clothes; slum dwellers and money. Stocks within the system: waste materials; solid waste residuals, both generated by waste picking and as household waste; groundwater, where also wastewater flows, in absence of any sewerage system.

Table 1 reports an initial inventory of inputs, stocks and outputs of the Gypsy camp located in Scampia (Napoli, S Italy). This inventory has the purpose of identifying the known and unknown variables of the system.

3.1.2 Solid waste and wastewater

Available accounted environmental indicators with respect to inputs and outputs of the Scampia Gypsy camp are reported in Table 2. Values and indicators are computed according to the method reported in the method section of this paper. The approximate total amount of collected waste by 140 people along a year, based on daily picking activity, considering that this informal economic activity is performed along the whole year, varies between 2.55×10^6kg and 5.62×10^6kg (equivalent to 0.5%-1.2% of the total waste produced along 1 year in the municipality of Napoli). Solid waste undergoes a sorting process for recovering the re-usable materials, such as metals, plastics and so on. These materials are, then, transported outside the camp and sold. No details are presently known about the amount of recovered solid waste by waste sorting, as well as about the number and characteristics of residuals generated by this activity and daily life of Gypsy dwellers. It is known from several newspaper reports that these residuals are burnt, generating uncontrolled atmospheric emissions. This is represented in Fig. 3 using a red arrow. However, further details are not available at the moment. Dispersed solid waste around the camp were evident from some field surveys. However, also in this case, details about waste composition and quantity are missing.

With respect to water, per capita water consumption, L_{pcd}, is obtained multiplying 0.79 m^3 water (this amount is derived from water costs per liter, then converted into m^3) by 41% (real value, considering water losses in the region). The obtained value is $3.22 \times 10^{-1} m^3$. In parallel, total water demand by Scampia camp is esteemed around 1.02×10^5 m^3. The esteemed production of wastewater (hydraulic charge, Q) along a year, calculated according to Eq. (1), is 8.18×10^4 m^3. The approximate estimations of BOD and TSS are, respectively, 2.11×10^2 g/m^3 and 2.46×10^2 g/m^3. Presently, the produced wastewater is dispersed in the environment, since no sewerage network is present in the area. This is represented using a blue arrow flowing outside of the system. Consequently, wastewater could potentially contaminate groundwater (as represented by the blue arrow flowing into the groundwater storage at the top-left of Fig. 3).

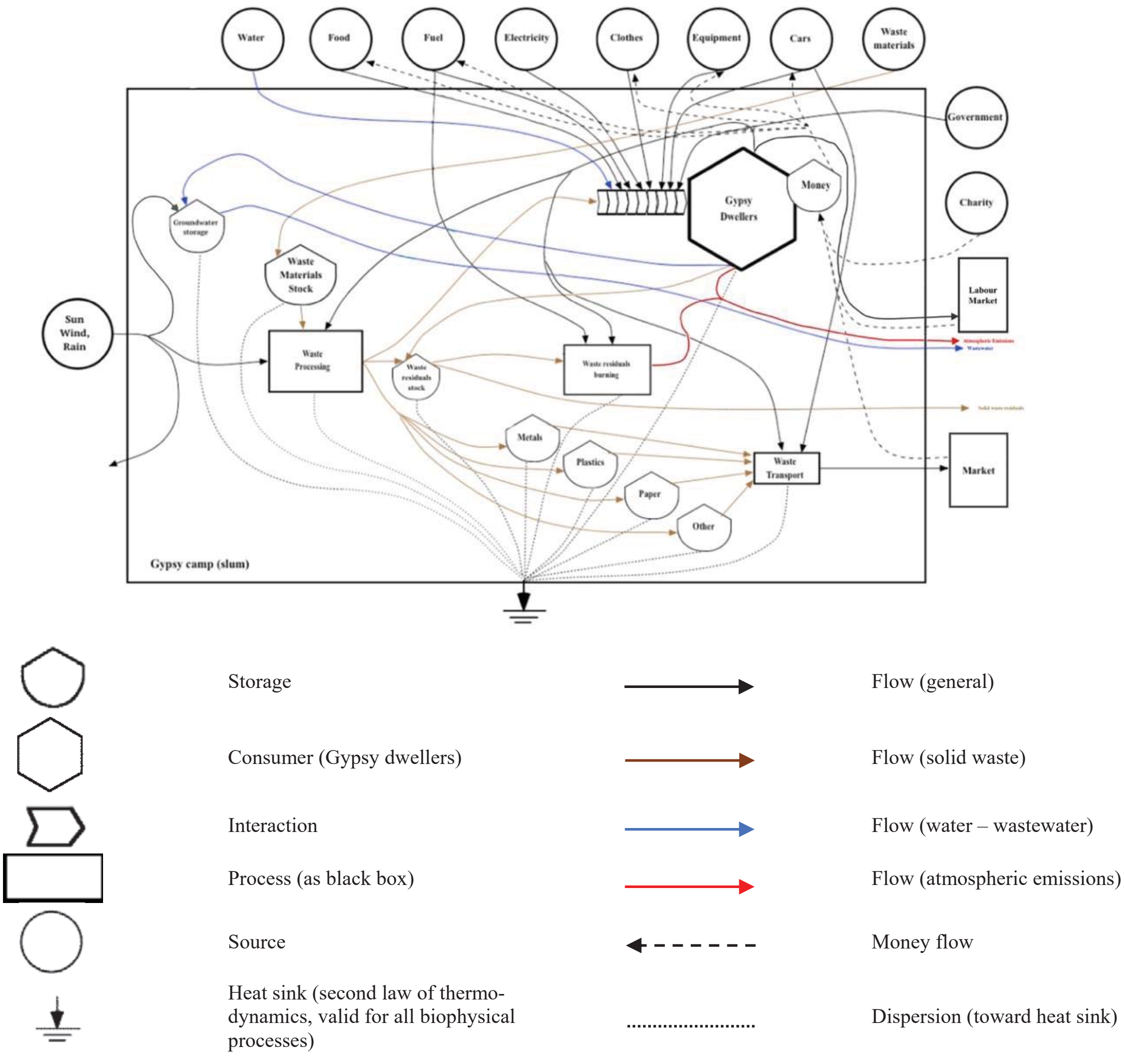

Fig. 3 Diagram representation of biophysical and economic dynamics within the Scampia Gypsy camp according to system diagram language developed by H. T. Odum and followers. On the left, the energy flows generated by natural resources (i.e.: Sun, wind, rain) are the natural input to the system. Above, other inputs are considered: water from public water distribution system; fuels, used by the slum dwellers for heating, cooking, as well as for transport (e.g.: cars); electricity, whose expenses are presently sustained by the Municipality of Napoli, as in the case of public water; solid waste materials collected through waste picking; clothes; slum dwellers and money. Stocks within the system: waste materials; solid waste residuals, both generated by waste picking and as household waste; ground-water, where also wastewater flows, in absence of any sewerage system.

3.1.3 Economic costs

The first part of Table 3 lists the management costs for the Gypsy camp in Scampia (Napoli, S. Italy) and foreseen remediation costs for the abandoned Gypsy camp in Brecce Sant'Erasmo (Napoli, S. Italy). Year economic costs for running the camp infrastructure were reported by BCLO (2013) thanks to a direct data collection. In particular, values, expressed in € and actualized for year 2017, are: 108,786.71 € (electric energy); 219,919.67 € (water); 64,261.71 € (maintenance). These services costs were sustained by the Municipality of Napoli to support the population of the investigated Gypsy camp. This represents a total year cost of 524.161.00 € (i.e.: each camp inhabitant produces a cost for the urban community of € 1,960.07).

The second part of Table 3 refers to the abandoned camp in Brecce Sant'Erasmo (Napoli, Italy), where

Table 1 Inputs, stocks and outputs inventory for the Gypsy camp located in Scampia (Napoli, S Italy).

Inputs	Stocks	Identified processes	Outputs
Sun, rain and wind	Solid waste materials (including building materials)	Solid waste sorting/processing (for recycling/reuse purposes)	Recycled/recovered materials from solid waste
Water (from public water distribution system)	Solid waste residuals (generated by household solid waste plus remains after solid waste materials separation for recycling/reuse purposes)	Solid waste residuals burning	Wastewater (flows into groundwater storage)
Fuel (unspecified use – it should include heating, cooking and transport)	Groundwater storage (represented as stock, where wastewater also flows, due to the lack of appropriate infrastructures)	Transport of recovered waste materials outside the camp (for sale)	Residual solid waste (from Gypsy dwellers and as residual of solid waste separation process)
Electricity (from public electricity distribution)	Money (represented as stock associated to Gypsy dwellers)		Atmospheric emissions (generated both from heating/cooking and waste residuals burning)
Solid waste materials (from which also building scrap materials are extracted)	Separate recovered waste materials (such as metals, plastics, etc.)		Money
Equipment (unspecified end use)			
Cars (the presence of cars owned by dwellers within the camp has been recorded, however their number is unknown)			
Clothes			
People (i.e.: slum dwellers)			
Money (derived from waste residual sale, formal economic activities and charity)			

remediation is planned for the future, whose costs haven't been investigated yet. However, knowing the latest-available average cost for waste management in Italy, referred to year 2015 (i.e.: 38.56 €cent/kg, as indicated by the Italian Institute of Statistics, ISTAT, and actualized to year 2017), it is possible to estimate the amount of money saved through waste scavenging. In particular, considering an individual daily picking capacity ranging from 50 kg to 110 kg and 140 people involved in this informal activity, the obtained money amounts, saved by the municipality of Napoli through waste scavenging by Gypsies, vary from 970,900 € to 2,135,980 €. As explained in the previous section, the second case area is used as a case study to develop a simple computation of remediation costs. This Gypsy camp should be treated as a complex brownfield. Using the data from EP-NRA (2008) as an esteem of remediation costs, actualized to year 2017, whose variability depends on the foreseen end use, are: 3,315,401.04 € (mixed use); 3,474,758.20 € (residential use); 3,315,401.04 € (mixed open space); 3,301,177.04 € (employment).

3.2 Discussion

Results of the present study show that our knowledge about slums is still approximate. In fact, previous studies didn't show or explained the real dynamics of resources within slums in order to improve the quality of life of its dwellers, as well as of the area surrounding these degraded urban areas. A first advancement toward this goal is given by the preliminary diagram representation and inventory of the slum, which could be further improved through necessary and appropriate field researches. The system shows its environmental-side weaknesses, when looking to the solid waste and wastewater dispersal, as well as to the uncontrolled atmospheric emissions, which

Table 2 Available environmental indicators inputs and outputs for the Gypsy camp in Scampia (Napoli, S. Italy).

Indicator	Unit	Value	Reference
Inputs (per day)			
Water consumption pro capite (L_{pcd})	m^3/(capita × day)	3.22×10^{-1}	Derived from water costs in the years 2005-2011 (BCLO, 2013)
Material input from individual waste picking	kg/capita/day	$5.0 \times 10^1 - 1.10 \times 10^2$	Minimum and maximum values (UN-HABITAT, 2010; Linzner and Lange, 2013)
Outputs (per day)			
Waste production	kg/(capita × day)	NA	No literature or field survey data available
Fraction of informally-collected MSW with respect to MSW produced in Napoli municipality on year base	%	0.5% - 1.2%	Based on Ripa et al. (2017) and on this study (i.e.: material input from individual waste picking).
Sewage flow (Q)	m^3/day	1.80×10^2	Derived from Von Sperling (2007)
Biological Oxygen Demand (BOD)	g O_2/m^3	2.11×10^2	Derived from Metcalf and Eddy (2004)
Total Suspended Solid (TSS)	g/m^3	2.46×10^2	Derived from Metcalf and Eddy (2004)
Emissions	NA	NA	No data available

Table 3 Management costs for the Gypsy camp in Scampia (Napoli, S. Italy) and foreseen remediation costs for the abandoned Gypsy camp in Brecce Sant'Erasmo (Napoli, S. Italy).

Indicator	Unit	Value	Reference
Management costs and savings			
Water services	(€/capita) per year	314.17	Derived from BCLO (2013)
Camp infrastructures maintenance	(€/capita) per year	91.80	Derived from BCLO (2013)
Money saved by waste picking (range)	€per year	970,900.00 - 2,135,980.00	Present study estimate based on mean Italian waste management costs and waste picking capacity (range) of Scampia camp population
Remediation costs ***(Site 2 – Brecce Sant'Erasmo)***			
Mean remediation cost	€(approximate cost – actualized to year 2017)	3,315,401.04 = = = 3,474,758.20 = = = 3,315,401.04 = = = 3,301,177.04	Derived from EP-NRA (2008). The site is considered as complex. The costs are considered for different final destination use (from top to down): mixed use; residential use; mixed open space; employment

should be carefully monitored. External resources inputs should be investigated at least with respect to fuels use, used equipment, used means of transport and clothes. The lack of separation between working and living spaces within Gypsy camps leads to a degradation of the studied area, which is perceived both by the dwellers and the other people living in the area. The evidenced environmental problems were partly evidenced in a previous study by Corburn and Sverdlik (2017): Inadequate sanitation access (in particular, absence of septic tanks and pour-flush or ventilated improved latrines); Hazardous housing sites (in particular, for environmental pollutants); Limited services and infrastructure (in particular, waste burning and lack of waste/wastewater management

Table 4 Environmental parameters for slum monitoring (source: Degert et al. (2016)).

Air quality	Land	Water	Biodiversity	Energy	Materials
• Air quality (gas and aerosol concentrations) • Ozone depletion • Direct emissions • Indirect emissions • Ozone depletion	• Site location • Present Land use (map) • Contaminated land areas • Planned land use (map)	• Surface and underground water systems • Water quality • Sewage treatment and disposal • Water availability • Water efficiency	• Protected area • Nature conservation • Aquatic ecosystems • Forests • Drylands • Environmental • risk management	• Energy efficiency • Energy sources	• Materials efficiency • Responsible sourcing • Whole life cycle analysis

infrastructures). Moving the attention to the management-side, public policies were developed in the last decades to upgrade these areas, which are environmentally and socially degraded. These include upgrading actions, provision of housing subsidies, clearing of informal settlements and residents' relocation, reduction either of costs or of building standards, as well as use of traditional low-cost technologies and materials (Wekesa et al., 2011). However, present approaches often lack of a coherent planning, which would make the upgrade effective. A first practical goal of planning should be the re-organization of spaces within these camps. It is known, in fact, that place attachment can grow if attractive and (still) familiar solutions are researched (von Wirth et al., 2016). Olthuis et al. (2015) established a set of recommendations with respect to the definition of tailored solutions: Accept the permanent nature of slums; Develop flexible solutions; Integrate customizable solution with local knowledge; Make pre-disaster investments.

Slum environmental monitoring should parallel the development of adequate solutions. With this respect, Degert et al. (2016) compiled a list of indicators (see Table 4), originally fixed and applied to a slum in Dhaka (Bangladesh), which should be applied for such a purpose. However, further environmental data could be collected to assess the environmental conditions on which the slum lifestyle depends. The approach to be applied could parallel the one used in environmental forensics, with consolidated methodology, considering that the origins of impacts are unknown. Thus, specific scenarios analysis techniques should be used, which include hierarchical monitoring through satellite and aerial platforms (Lega et al., 2010; Lega and Persechino, 2014; Lega et al., 2014; Lega and Endreny, 2016; Leonita et al., 2018), geophysical surveys (Di Fiore et al., 2017) and intensive environmental monitoring approaches, such as the ones used in environmental nowcasting, which integrate measures and modelling techniques (Casazza, 2015). A three-dimensional approach a framework, which could be implemented from a study by Lega et al. (2018), would be desirable to implement specific models of informal settlements, as the one described by Rautenbach et al. (2015).

This investigation determined that approximately 1% of MSW generated by Napoli municipality are recovered and, then, reused or sold by Scampia camp population. In this way, waste scavenging, which contributes to a reduction of materials extraction, and scrap materials reuse would be coherent with circular economy principles. In fact, reduction, reuse and recycling jointly represent the 3R principle of circular economy (Tisserant et al., 2017). According to the definitions given by Kalmykova et al. (2018), by-products use (i.e.: byproducts from other production chains are used as raw materials for manufacturing new products), downcycling (i.e.: converting used products into different new products of lower quality) and elements recovery (i.e.: materials recovery from a material waste stream), which are coherent with circular economy principles and practices, are among the purposes of waste picking. However, the implementation toward a circular economy paradigm might be difficult, as reported in a study by Tong and Tao (2016). In fact, going to a community level, NIMBY conflicts might arise due to potential value conflicts among urban residents and the informal recyclers. Thus, this study stressed the relevance of inclusion of informal recycling sector as a stakeholder in searching for appropriate planning solutions. Solutions must be found with respect to the stocking and removal of residual solid waste within the camp, in order to avoid its dispersal. In particular, it should be envisioned the development of a specific working area and, close to that, of specific spaces for a separate collection of solid wastes under safe conditions. With this respect, a field research and intervention in the slum of Dhaka showed that, developing local interviews and discussion groups activities on waste bins use, it is possible to obtain a positive outcome and better management of generated waste in slums (Yeasmin et al., 2017). Moreover, a value chain analysis can be applied to improve the whole process of recovery and recycling activities, as already done in Zabaleen (Egypt) (Jaligot et al., 2016).

Scampia camp water consumption pro capite is comparable to the one of a large city with more than 250,000 inhabitants (Von Sperling, 2007), but lower with respect to the reference daily value for Campania Region (436 L/capita, according to Viceconte (2006)). BOD values are lower than the ones for typical raw wastewater ones (280 g O_2/m^3) and close to moderate-type wastewater, which have a reference value of 250 g O_2/m^3 (Henze et al., 1997). Prognostic TSS values calculated in this study, according to the same reference, have values, which fall between diluted- (reference: 190 g/m^3) and moderate-type (reference: 300 g/m^3) wastewater. The main critical point for Gypsy camps, as in the case of Scampia, is the absence of any sanitary infrastructure for waste and wastewater collection. This worsens the environmental impacts of such a temporary settlement, similar in nature to other Gypsy camps in Italy. It is important to stress that this situation is also reflected into remediation costs, which become higher. The first problem in managing solutions for wastewater would be to develop a shared knowledge basis about wastewater disposal among the inhabitants of the slum, scientific experts and the municipality, as suggested in the case of Delhi informal settlements (Karpouzoglou and Zimmer, 2016; Robina Ramírez and Sañudo-Fontaneda, 2018). Multicriteria analysis can be adopted to define necessary actions, following five different dimensions of Integrated Water Cycle Management concept (IWCM): collecting, draining, purifying, transferring back and reusing. This analysis, which integrates all the water users, including natural environment, was successfully applied for a slum in Algiers (Algeria) (Aroua and Berezowska-Azzag, 2014). In parallel, locally-adapted and efficient solutions are already available for upgrading the management of wastewater (Larsen et al., 2015; Larsen et al., 2016). In particular, decentralized treatment of faecal sludge generated from pit latrines is possible, since it was successfully tested by Semiyaga et al. (2017). Another research assessed the option of introducing prefabricated biogas reactor-based systems for community wastewater and organic waste treatment (Cheng et al., 2014). In parallel, anaerobic membrane bioreactors (AnMBR) can support onsite sanitation, as well as resource recovery (nutrients, energy and water) in urban slums (Bair et al., 2015).

4 Conclusions

The outcome of this preliminary research represents a contrasting scenario. In fact, while several public policies are discussed in order to improve the life quality of slum dwellers and to reduce the existing environmental impacts of slums, there is a general lack of knowledge about existing resources flows and processes within a camp. Moreover, these areas lack basic infrastructures and separation between living and working spaces. The informal activity of waste picking, even if involving a small percentage of the community members, represents a special case of waste reuse, becoming a possible example of circular economy application. However, the benefits are counterbalanced by the impacts. In particular, solid waste abandonment, dispersed wastewater and atmospheric emissions. Upgrade actions, together with a participatory zoning and management plan of these areas, conversely, would reduce both economic costs, which are sustained by the urban communities, as well as remediation costs, in case of abandonment of the camps. Research is necessary to develop an appropriate understanding of biophysical and economic flows within slums. Then, the environmental and economic dimensions should be integrated with the social one, in order to promote new effective and more inclusive public policies.

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