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Chapter 1

Introductory Chapter: Rural Waste Management Issues at Global Level

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http://dx.doi.org/10.5772/intechopen.70268

1. Introduction

Different technical and social innovations may be required for solid waste management sector in large cities and rural areas as particular geographical regions [1]. Despite the fact that dumps represent the worst-case scenario in current waste management practices in terms of environmental protection and sustainability, they still occurred across the globe, particularly in peri-urban and rural regions. Developing countries are facing the transition from the dumps to the implementation of the first sanitary landfills. Former communist countries are facing serious challenges in the closure of "conventional landfills" which do not meet the criteria of the EU Landfill Directive 1999/31. Some of these sites must be upgraded in order to comply the current EU standards, and new integrated waste management system must replace the obsolete infrastructure. Sweden, Denmark, and Germany have developed their waste management toward "zero waste landfill," while other countries such as the USA, India, Brazil, and Qatar still use landfilling as the main option in their waste management [2].

Developed, transition, and emerging countries did not eradicate the wild dump issues. Despite the fact that these sites are smaller than formal urban landfills and scattered across peri-urban and rural regions, they are still a significant pollution source. Wild dumps must be mapped at municipal level across all regions in order to assess their environmental impact [3, 4]. Monitoring of illegal dumping activities is crucial either in high-income countries affecting public lands, roadsides, or water bodies [5–7].

The dump is historically the basic and most convenient option in the waste management treatment used by human settlements across the globe along with ocean and river dumping practices.

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The lack of governmental policy and finance, difficulty in political issues and long-term planning in waste management, social behavior, and resistance to change in, for example, separation of wastes at source, regular waste collection services, poor waste management infrastructure, low quality of waste management services, lack of funds, poor environmental awareness, low market for recycled materials, all these factors contribute to the existence of open dumps nowadays [2].

The wild dumps are encountered in the peri-urban and rural areas due to the lack of waste and sanitation facilities. Frequently, such uncontrolled disposal sites are located in the proximity of households and water bodies. The dumps are a source of complex pollution (air, water, soil, and biodiversity) which threatens the public health. Mixed waste fractions (municipal, agricultural, construction and demolition, WEEE, bulk items), including hazardous streams, are disposed in such sites causing serious public health issues.

In some cases, such dumps are heavily pollution source due to the illegal disposal activities practiced by the mafia in southern Italy (so-called mob dumping). Particular geographical areas are outlined such as "triangle of death" in Campania region (area between Acerra, Nola, and Marigliano municipalities) or the extended area called "Land of Fires" which includes 88 municipalities across Napoli and Caserta provinces [8]. The magnitude of toxic dumping practice is a severe issue for an EU country where statistically all population have access to reliable waste management services. This fact points out that developed countries may have serious gaps in their waste management systems which favor the existence of such wild dumps scattered across rural areas of fly-tipping practices (the USA, Australia, the UK, Mediterranean countries, Central and Eastern Europe). In fact, the "Let's do it! World" movement is a supplementary evidence to this current global environmental issue.

As an example, in the 1990s, in rural Greece there was estimated over 3500 such sites where wastes were illegally disposed without any further treatment (natural depressions, old quarries, gullies, or torrents) [9]. By the mid-1990s, the government of Israel started to replace all unregulated dumps with a rationalized system of large-scale regional landfills [10]. Same threats occurred in the USA [11], and special waste management actions were necessary for rural and remote communities in Canada [12]. New EU members should close and rehabilitate the rural wild dumps until 16 July 2009; meanwhile, the EU candidate countries are expected to solve the problem of wild dumps across rural communities.

Traditional recovery of household waste at the household level, home composting, and animal feed has diverted a part of biowaste fraction from waste dumping into these applications. The improvement of home composting procedure across rural communities is a cost-efficient and an environmentally friendly solution if it is properly performed avoiding the biowaste losses [13]. Reuse and recycling of various items (glass, plastic bottles, construction material, and metal) at household level also mitigate the potential amounts of waste uncontrolled disposed. Frequently, the rural population of low- and middle-income countries relies on solid fuels (firewood, dung, and crop residues) as the energy source for domestic purposes.

Wood, sawdust, paper, and cardboard fractions are used for direct burning as the heating energy source at household level or animal manure in regions without access to forest areas (e.g., high plateau).

Unfortunately, in developing countries, the traditional furnaces are primitive mud stoves and ovens that are extremely air polluting and highly energy inefficient [14]. The incomplete combustion of solid biomass or burning at lower temperature than 800°C leads to exposure of particulate matter (PM), carbon monoxide (CO), oxides of nitrogen and oxides of sulfur (SO_x, NO_x), and phosgene, which has been linked to high morbidity and mortality rates across developing countries [15].

Agricultural wastes (e.g., straws, stalks, husks, wood, and sawdust) are often disposed by burning in open fields with exposure to fire hazard. Household waste (biowaste, plastics, textiles, etc.) are also prone to open burning practices. Mixed wastes may contain hazardous items (e-waste, batteries, oils, solvents, paints, contaminated wood, and pharmaceutical products) which are released into the atmosphere, soil, and groundwaters. The common hazardous substance used in the rural area includes insecticide, pesticide, fungicide, herbicide, chemical fertilizers, chemicals used for fumigation, cleaning agents used in animal husbandry, and medical waste [16]. Such hazardous fraction must be separated, collected, and managed from common household waste.

In worst-case scenario, rural households may have no access to basic utilities (improved drinking water source, sanitation, waste management services), and the near water bodies are polluted by waste dumping and open defecation. In developing countries, especially in rural areas of Africa, India, and China, human waste disposal is a major concern besides household and agricultural waste [17].

There are major gaps in waste collection coverage between larger cities and rural regions across developing and transition countries. A recent study estimates that 1.9 billion people lack waste collection services in rural areas and coverage rate of rural population is under 50% in 105 countries [18]. The amounts of municipal waste generated and uncollected by waste operators or public sanitation services are susceptible to be burnt or uncontrolled dumped, polluting the local environment and threatening the public health. Such wastes pollute the tributaries and rivers, lakes, and coastal areas; thus, floating debris invade marine and ocean ecosystems. Plastic pollution in particular non-compostable microplastics is a notorious threat to marine wildlife, and large areas of oceans called "gyres" concentrate such plastic debris due to the currents (e.g., North Pacific Gyre).

Rural regions without access to formal waste collection services must be encouraged to practice home composting or vermicomposting in order to obtain a qualitative natural fertilizer. Organic farming seeks to reduce external cost, produce good yields, save energy, maintain biodiversity, and keep soil healthy [14]. Composting process may cover various biowaste sources (municipal, sewage, and agricultural) diverting such fractions from open dumping or open burning practices.

If all global domestic wastes derived from organic materials that every year leave the croplands (6.8 billion tons) would be treated by the anaerobic/aerobic process, it could be produced about 4 billion tons of very good soil, avoiding the emissions of 1.4 billion tons of CO_2 eq [19].

Sparsely rural areas which are remote from major urban areas are usually the most neglected by waste management services. Waste operators avoid such areas, and local authorities provide no or low financial resources to provide appropriate public services. In addition, the geographical constraints (mountains, hills, high plateaus, karst regions, and wetlands) makes more difficult to implement proper waste management facilities.

The four cornerstone technologies for agricultural waste and organic fraction of municipal solid waste (OFMSW) suitable for rural communities are animal fodder, briquetting, anaerobic digestion (biogas), and composting with other recycling techniques for solid wastes [14]. Such facilities may serve rural communities without access to formal waste management systems specific to urban areas. These technologies may be integrated into one rural waste complex in order to achieve a desirable zero waste and pollution target [14]. Small anaerobic digesters which use agricultural and food waste may be operational at household level in order to obtain energy (biogas) for cooking and other basic needs. Materials of construction and the design of such digesters are varied based on the geographical location, availability of substrate, and climatic conditions [20]. Thus, in China there are more than 30 million household digesters, India there are 3.8 million, followed by Vietnam with more than 0.5, and Nepal 0.2 million and Bangladesh with 60,000 digesters, while farm-scale digesters are expanding in Europe, the USA, and Canada [21]. Despite the African countries made recent progress on the field where 2619 domestic digesters were installed in 2012 [22], such facilities are still poor exploited due to less availability of technical and operational support, poor digester designs, maintenance, planning, monitoring, lack of awareness, and inadequate dissemination strategy [23]. The common designs include fixed dome (widespread in China), floating drum (widespread in India), and plug flow type (the USA, Peru, etc.) followed by other derivates [20].

In many cases, animal manure, agricultural plant residues (straw, garden wastes, roadside grass), and food waste (OFMSW) are co-digested together to achieve a better nutrient balance in anaerobic digestion process [24]. Community-type biogas digesters have larger volume, and they can produce biogas for several homes instead of one household. Furthermore, public toilets are connected to biogas digesters in India and Nepal [20]. Decentralized facilities are suitable in remote rural regions from which may benefit both industrialized and developing countries. Various geographical regions may provide different biowaste fractions as feedstock for anaerobic digestion process as shown in Nigeria [23].

Biowaste treated in a household biogas digester provides energy for cooking, lighting, and heating along with an improved organic fertilizer in the digest for farmers [20]. The subsidies from the government or local authorities could expand the use of household biogas digesters across rural communities reducing the landfill of biowaste, thus mitigating the Greenhouse gases and leachate emissions into the environment. Developing a user-friendly technology and making it economically viable will enhance the use of biogas digesters which are a boon to low-income and rural people [25].

Large and expensive anaerobic digestion plants and central composting facilities are encountered in regional integrated municipal waste management systems of developed countries which cover cities and surrounding rural areas. Biogas technology is a proven and

established technology in many parts of the world such as Germany, the UK, Switzerland, France, Austria, the Netherlands, Sweden, Denmark, Norway, Republic of Korea, Finland, Republic of Ireland, Brazil, China, and India [23].

The European Union imposes that every member state must to reach a 20% share of renewable energies in the total energy consumption by 2020 and to reduce the amount of biodegradable municipal waste that they landfill to 35% of 1995 levels by 2016 (for some countries by 2020) under the Landfill Directive (1999/31/EC). In this context, anaerobic digestion plants could emerge in following years across Europe as alternative energy source to fossil fuels encouraging the transition toward a circular economy approach.

Centralized composting plants usually have as main feedstock the OFMSW of urban areas. However, metropolitan and surrounding rural areas may also contribute with significant amounts of OFMSW in the case of a widespread source-separation collection schemes. The population must be aware that a clean source-separate of biowaste and dry recyclables will improve composting and recycling activities. Intermunicipal cooperation between cities and rural municipalities is mandatory for a successful regional waste management system.

Low technological composting plants should be implemented in rural areas, while in high-density areas, combined anaerobic and aerobic plants with mechanical pretreatment (MBT plants) are preferable due to higher impurities of OFMSW [26].

Waste transportation from source generation (villages) to treatment facilities (transfer station, recycling centers, composting plants, waste to energy plants, and landfills) is a key logistic issue across rural regions.

The budgets of local authorities allocated for waste management sector are limited. Waste management associations group several municipalities or even an entire county/region in order to economically sustain the waste management services.

Major investments are required in order to expand the waste management services from larger cities toward towns and rural localities. EU funds plays an important role in this matter in the case of Central and Eastern European Countries. EU landfill Directive imposes all member states to close the non-compliant urban landfills and rural wild dumps. These are being replaced at the county level by transfer stations, waste to energy plants, or regional sanitary landfills. On the same sites, sorting stations, composting facilities, and crushing plants (construction and demolition waste) may be operational in order to optimize the costs. These integrated waste management systems are based on separate waste collection schemes ("door to door," collection points, and civic amenity sites).

Mixed waste collection must be replaced by such facilities in order to achieve a high rate of waste diversion from landfill sites.

There are two main routes which can help worldwide rural communities to achieve a sustainable waste management system as shown in **Figure 1**. Both routes can be applied at regional level taking into account the specific geographical conditions (natural and socio-economic) which may vary at different scales (village, municipality, county, region, and country).

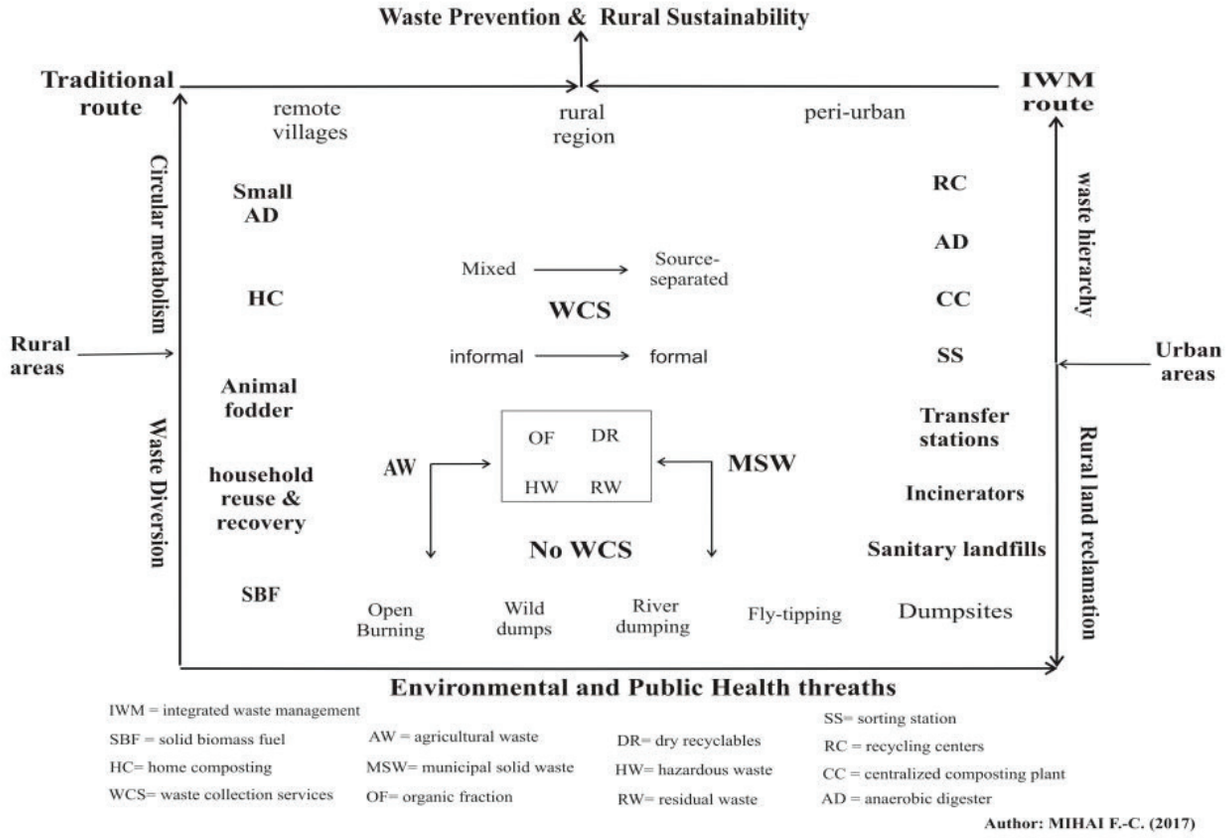

Figure 1. Routes toward waste prevention and rural sustainability.

The rural waste management must rely on a systemic approach involving technical, financial, social, cultural, environmental, and governance aspects. Developing and transition countries must promote smart traditional ways to recycle, reuse, and compost/digest the municipal and agricultural wastes from remote rural regions in order to increase the waste diversion rate from uncontrolled waste disposal practices (open burning, wild dumps, and river/marine dumping).

Generally, rural areas of high-income countries (HIC) are full covered by waste management services in contrast with upper-middle-income countries (UMIC) where the rural population is partially served or low-income countries (LIC) where such services are poor or nonexistent.

In developing countries, informal sector plays a crucial role in diverting recyclables from waste dumping and to provide basic waste collection services, but it is mainly developed in urban and peri-urban areas. Local authorities from many Asian countries operate under severe constraints such as endemic persistence of poverty, unemployment, and underdevelopment which lead to a large informal sector [10]. Animal-driven carts, tricycles, and tractor trailers are frequently used for the transportation of waste across rural communities. The waste management infrastructure is rudimentary; the amounts of waste collected are frequently disposed on open dumps or river banks.

The costs of waste management activities are a heavily burden for small cities and rural localities of developing countries. Such areas are facing a cruel poverty which encourages migration of inhabitants toward urban areas with hope for a better life. Unfortunately, the rapid migration leads to the development of slum areas with the severe challenges in terms of sanitation and waste collection services. On the other hand, urban residents perceive rural areas as sources of raw materials or as places where the most polluting productive activities belong [27]. Environmental injustice operates toward rural areas where urban waste is disposed through large dumpsites, landfills, incinerators, or land application of sludge from urban wastewater [28].

Environmental pollution only seems to be dissipated across sparsely rural regions, but the threats remain at the same level as for urban areas. Furthermore, the pollution activities that occurred in rural areas are more predisposed to be made in an uncontrolled manner. The poor monitoring process and law enforcement lead rural areas to be vulnerable to such practices in both developed or emerging economies.

Home composting and biogas production via home or community digesters are suitable alternatives for rural communities across developing and transition countries where the share of biowaste in the total municipal solid waste fraction is significant and agriculture plays a key role in their economy. However, these practices must be properly performed at the local scale in order to achieve a viable solution for energy and fertilizer demands. Environmental awareness and proper training are crucial to being further developed via governmental programs, local authorities, and civil society. Local municipalities must be supported by financial instruments (subsidies, soft loans, tax incentives, national and international funds) to provide proper facilities for biowaste management.

The regionalization process of waste management infrastructure aims to mitigate the environmental pollution and to expand standardized waste management services across towns and rural municipalities. However, the bureaucracy and delays in the construction process of waste management facilities may lead to serious problems at regional level [29].

Rural-urban relations must be integrated into a sustainable cohesion policy concerning public utilities with a special focus on solid waste management sector.

2. Conclusions

This book intends to draw attention to solid waste management sector toward rural areas where bad practices and public health threats could be avoided through traditional and integrated waste management routes. The expansion of waste collection services across rural municipalities should be a priority for many countries. Agricultural and municipal waste diversion from wild dumps and open burning practices must be avoided through smart solutions at the local level which are cost-efficient particularly in developing countries. The book further examines, on the one hand, the main challenges in the development of reliable waste

management practices across rural regions and, on the other hand, the concrete solutions and the new opportunities across the world in dealing with rural solid waste.

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