Innovation in waste recycling operations

The scarcity of natural resources, coupled with waste disposal problems, has led humans to improve recycling practices. According to the Ministry of the Environment, "About 30% of all 'garbage' consists of recyclable materials with market value, as they are reused as raw materials in the manufacturing process of new products." Following this line of thinking, COMAREI - Cooperativa de Materiais Recicláveis de Itu (Itu Recyclable Materials Cooperative) - contributes to this work in the municipality, being fully responsible for selective collection. Considering the increase in unsustainable consumption and the increase in the volume of household waste, this study proposes the application of new techniques that facilitate the sorting process and bring financial and social results to the cooperative.

In the municipality of Itu, with a view to minimizing the waste problem, COMAREI (Itu Recyclable Materials Cooperative) was established, which contributes to the work of collection, processing, and disposal, being fully responsible for selective collection.

Located 101 km from the state capital, the tourist resort of Itu has 160,608 inhabitants, with a population density of 251.11 inhabitants/km² and a degree of urbanization of 93.59% (SEADE, 2014). According to the same source, living conditions in the municipality show a Municipal Human Development Index (IDHM) of 0.773. As for the environmental conditions of urban infrastructure, the SEADE Foundation (2014) reports that 93.64% of the municipality is served by regular garbage collection, 98.69% of the population has water supply, and 96.62% has sewage systems.

Considering the increase in unsustainable consumption and the increase in the volume of household waste, the collection of recyclable waste is essential for improving urban environmental conditions, which highlights the importance of COMAREI's activities.

The waste produced in cities is becoming increasingly problematic for two main reasons: the number of people living in urban areas has grown significantly, generating ever-increasing volumes of waste, and the evolution of industrial development techniques and processes is producing more and more types of waste that nature cannot destroy, such as non-biodegradable waste.

Conceição and Medeiros (2009), in a study resulting from research on the formation of cooperatives, associate recycling with the current capitalist model as an economic instrument. They also refer to globalized exploitation, where recycling is accepted as a way to make up for the lack of raw materials, paying a much lower price compared to virgin raw materials and reducing production costs. They conclude that "pro-capitalist" sustainable development, in which recycling itself does not represent an economic alternative, much less an

environmental one, only temporarily alleviates social pressures on unemployment among the excluded and provides a gain for industries by reducing their costs, and these industries, using scrap dealers, control the market for recycled products.

COMAREI has its own organization and management and is not dependent on public agencies, but it is linked to the Itu City Hall for some actions and/or interventions, such as partnerships and donations. With the increase in the supply of materials, the price paid by purchasing industries will fall, increasing the exploitation of waste pickers, who largely sustain the economic viability of recycling (EIGENHEER, FERREIRA, AND ADLER, 2005). However, studies in several Brazilian cities have shown that the income of waste pickers organized in cooperatives, in most cases, exceeds the minimum wage, with these waste pickers earning above the Brazilian average (D'ALMEIDA and VILHENA, 2000).

Carvalhal (2010) highlights that cooperatives/associations are a way of reducing the social insecurity faced by waste pickers, allowing them to carry out their work in these locations without being exploited by middlemen or third parties, and enabling them to add value to their work by assigning a more significant value to the sale of recyclable materials. In the vast majority of studies related to this issue, the precarious nature of the work of those who deal with the collection of recyclable materials and the informality involved are evident.

In his work on selective collection programs in partnership with waste picker associations, Besen (2006) adds that the instability of sustainable management programs is related to the low rate of selective collection (in relation to the potential amount of material that could be recycled), the high rate of waste mixed with recyclable material, informal competition from independent waste pickers, and the fragility of agreements signed with city governments.

Troschinetz and Mihelci (2009) also list the following as government policies: the characterization of waste produced, the separation of materials, the economic condition of residents, solid waste management, the technical preparation of the team responsible, the management plan, the local market for the sale of recyclable materials, the level of education of residents, available technological resources, among others.

In recent years, academic work involving recycling, reuse, and reuse of materials and energy resources has been developed, aiming not only at the management and adaptation of environmental laws, but also at gains from an economic point of view, using new technologies or highlighting the importance of reverse logistics resulting from selective collection (MATOS and SCHALCH, 2007).

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Further Reading

SILVA, L. P. et al. Indústria 4.0 e a Transformação Digital nas Operações de Reciclagem de Resíduos Sólidos Urbanos no Brasil: Análise de Eficiência e Sustentabilidade**.** Engenharia Sanitária e Ambiental**,** v. 29, n. 1, p. 145-162, 2024.

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