International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 1137-1140 www.ijaem.net ISSN: 2395-5252

Integrated Solid Waste Management as a complex system: Reflection review note

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Date of Submission: 15-10-2022 Date of Acceptance: 31-10-2022

ABSTRACT:
Integral Waste Management is a shared responsibility among many stakeholders, it requires the joint, coordinated, and differentiated participation of all producers, importers, distributors, consumers, and waste managers, both public and private, as well as local and State governments. Proper waste management minimizes future negative consequences for the environment and the health of the population in general.

KEYWORDS: Waste Management, Costa Rica, Enginehead, L293D Current Amplifier, IRF 3205 MOSFET.

I. INTRODUCTION

According to Britannica"Solid-waste management, is the collecting, treating, and disposing of solid material that is discarded because it has served its purpose or is no longer useful. Improper disposal of municipal solid waste can create unsanitary conditions, and these conditions, in turn, can lead to pollution of the environment and outbreaks of vector-borne disease—that is, diseases spread by rodents and insects."[1].

In Costa Rica, there is extensive legislation related to waste management [4, 5]; however, some gaps still become more evident in special situations and climate emergencies.Currently, accordingto Peña Bonilla [2], cited by Carolina Rojas Brenes [3],70%of urban floods originate from waste in sewers, causing millionaire losses in infrastructure and resources, as well as evacuations, the establishment of shelters, and mobilization of emergency teams such as police, firefighters, among others. This waste, when dragged by bodies of water affects the turbines of hydroelectric power generating plants, so a considerable amount of moneyis spent annually cleaning the different water reservoirs.This reviewpresents note isa reflection on Integrated Solid Waste Management (ISWM) from the point of view ofcomplex systems [6, 7, 8].

II. INTEGRATED SOLID WASTE MANAGEMENT (ISWM) AS A COMPLEX SYSTEM

Morin's theory of complexity and complex systems applies it to a wide-ranging number of issues. This approach stimulates critical debate and is also essential for anybody interested in understandingour complex world [6, 7, 8].

As a System, the ISWMhas four basic parts: limits inputs, outputs, components, and interaction between components [9].These can be extended to six basic elements that make up the functional elements of a solid waste management system(Figure 1), they are 1. The production of solid waste or Generation; 2. Handling and storage on-site; 3. Collection; 4. Transfer and transport; 5. Recovery and Waste Processing; and 6. Disposal of waste [10].

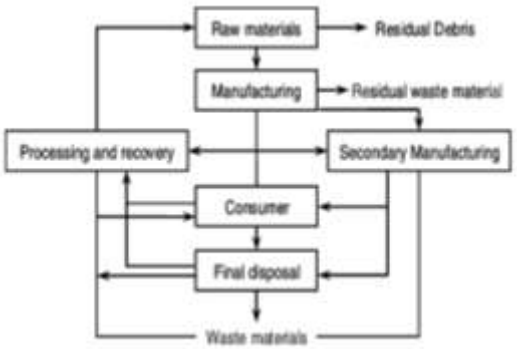

Figure 1.Functional elements of a solid waste management system. Source: [10].

III. THE ENVIRONMENTAL PROBLEM

The issue of solid waste has become one of the most important for people interested in environmental conservation. Society faces the daily generation of a large amount of waste, pollution of the environment by hazardous waste, problems in

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population centers due to the accumulation of waste, the spread of diseases through insects and animals that live on poorly managed waste, exhaustion of landfills and refusal of peoples to receive a new one, just to name a few. Among the factors that aggravate this environmental problem is the lack of knowledge of

the population about the activities and habits that contribute to pollution, current legislation, and measures to reduce environmental impact and better manage waste. Therefore, it is important to have the basic knowledge that allows an understandingof the dimensions of the problem and how to implement the waste management hierarchy, promoting prevention and reduction, then reuse and recovery, and finally treatment and final disposal [11].Edgar Morin [7, 8] has been urging for a shift towardcomplex thinking for many decades. The author has an exclusive capability to move between the natural and social sciencesand is ideally placed to address our times' epistemological, ethical, and practical problems. What makes Morin unique among complexity theorists is how he turns a critical eye on complexity theory itself, resisting a return to determinism, reduction, and disjunction in come approaches to complexity [12].

Therefore, finding a way to integrate all the components of the ISWM from the paradigm of complex thinking is presented as an opportunity to consider them integrally and interactively, not always linear.In contrast, the proposal to approach ISWMs from complexity and study them through complex systems, including local knowledge,gender, social welfare, social inclusion, and job rights, isa non-linear and rhizomatic way, which allows us to involve other aspects not considered in conventionalapproaches.

IV. CHARACTERISTICS OF SOLID WASTE

Costa Rican Law Number 8839 for the integral management of waste [14] establishes some definitions of waste:

•**Waste:** solid, semi-solid, liquid, or gas material, whose generator or holder must or requires disposal of it, and which can or should be recovered or treated responsibly or, failing that, be handled by appropriate final disposal systems.

•**Hazardous waste:** are those that d to their chemical reactivity and their toxic, explosive, corrosive, radioactive, biological, bioinfectious, and flammable characteristics, or that due to their time of exposure can cause damage to health and the environment.

• **Ordinary waste:** household waste generated in dwellings and in any other source, which presents compositions similar to those of dwellings.

Waste of special or hazardous handling, regulated in this Law and its Regulations are excluded.

Also, Law 8839 establishes in article 4 a hierarchy for the integral management of waste that is transcribed below [14]:

• **Avoid** the generation of waste at its source as a means to prevent the proliferation of vectors related to infectious diseases and environmental pollution.

• **Reduce** as much as possible the generation of waste at its source.

• **Reuse** the waste generated either in the same production chain or in other processes.

• **Recover** waste through recycling, co-processing, assembly, or other technical procedure that allows the recovery of the material and its energy use. Priority should be given to the recovery of materials over energy use, according to technical criteria.

• **Treat** the waste generated before sending it to the final disposal.

• **Dispose** of the least amount of waste, in a sanitary way, as well as an ecologically appropriate.

V. GUIDE FOR THE ELABORATION OF THE ENVIRONMENTAL MANAGEMENT PLAN FOR SOLID WASTE

In Costa Rica there is a guide to developing the environmental management plan for waste, it details the necessary data to know the solid waste generated by the generating source as 1. The necessary physicochemical analyses will be submitted to the Ministry of Health by type of waste. 2. The tests, studies, and analyses of the residues will be carried out by certified third parties. 3. A statistical report will be presented indicating the volumes of waste generation in the generating source, so that the current daily, monthly, and annual generation can be known. 4. If the waste or any of the waste is classified by the Ministry of Health as hazardous, the generating source must proceed to modify the plan according to the management characteristics established for the waste, in addition to indicating its separate management from ordinary waste.

VI. FINAL CONSIDERATIONS

Looking back on this review project, the overall outcome of the results is very realistic. According to the State of the Nation Report 2019 [16]the collection of solid waste in the country despite the obligation to have a selective collection

system for recoverable waste, there are 87 districts of the 481 in the country, which does not have a municipal collection, forcing them to resort to inappropriate practices such as burning garbage, dump it in vacant lots or bodies of water [17].Other studies say that the production of solid waste reaches 4000 tons per day, the final whereabouts of almost a quarter of this waste are unknown, and 264 tons of waste are recycled per day. The rest of the waste is managed in landfills or dumps that in many cases are in the process of technical closure. Studies of waste composition indicate that just over half of these are compostable while a third are recoverable, so 14% of the country's waste, only 560 tons per day must be deposited in landfills and landfills. Inefficient waste management involves major environmental, economic, and social problems [18, 19, 20].

This review note is not intended to be conclusive, but to be preventive of the environmental effects of waste and its management. Specifically in the context of climate change, waste constitutes an important source of Greenhouse Gas (GHG) emissions, the National Greenhouse Gas Inventory indicates that the waste sector is the second largest net emitter in Costa Rica, only surpassed by the energy and transport sector. In 2017 this sector generated in Costa Rica 2,138,500 tons of carbon dioxide equivalent[21], to put this number in context, this amount represents 14.8% of the total emissions of the waste sector. Although the country has a Law for Integral Waste Management [4] and an Integrated Waste Management Plan (IWMP) [5] whose objectivesare to reduce waste disposal, there are still gaps that can be improved. Promoting the creation of regional projects in order to facilitate the articulation between different actors for the integral management of waste, transforming them, and reincorporating them into the economy would be one of the ways to do it according to the IWMP [5].

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