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Industrial Solid/Hazardous Waste Recovery and Management in India: A Conceptual Nexus of Circular Economy

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ABSTRACT

The study focuses on Industrial Solid waste management in red classified (21 most polluting industries) India. It depends on the concept of Economic, Environmental, regulation, technology like recycling, reduction, reuse, industrial ecology, re-engineering, incineration, pyrolysis, landfill, and trade-off with negative and positive externalities towards the strict regulation, policy, and incentives to the acceptable standards India's pollution control authority has issued a statement for the up-gradation/updating of the solid/ hazardous waste in a mixed combination. The method used is exploratory research investigated through SWOT analysis with an interview schedule. The study envisages every important practical concept like clean development mechanism intervention with a mixed raw material analysis and resilient circular economy on the resources substitutions; this has an importance on developing the relationship between the institutional research and development of waste management platform, monitoring, and assessment, Clean and green production, bio-remedial technologies Waste-to-energy, Organic biomass, Biofuels, Biochemicals, composting These described critical gaps, new marketing opportunities, resources management, conservation and challenges maintaining database management for meta-analysis,The risk assessment, and life cycle analysis in Supply Chain and cradle to cradle concept. The outcomes of the study are to understand the raw material resource management, Industries with mixed resources, recycling market from waste to material, sustainable development, standard operating procedures, and mathematical data modeling using multicriteria and environmental decision support system towards the future technologies with energy, environmental, safety and quality assurance audit.

Keywords: Circular economy, Industrial solid/hazardous waste management, Mixed raw material, End of life, Material resource analysis, SWOT analysis, multicriteria, and environmental decision support system.

I. INTRODUCTION

The treatment of industrial solid waste is complex on a global scale. It depends on the material used, and it's an essential part of improvising technology

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and cost reduction now; this sector has been a vital business waste of money. Due to the trade-off has been a critical commodity, and the cutoff value brings a negative externality **(**Zvarych 2017, Goel 2017, Zhang et al. 2022c**).**The circular economy (CE) business model plays an essential role in overcoming problems like Reuse, recycling, reduction, Reuse, re-engineering, industrial ecology, energy from waste co-processing material, depending upon the manufacturing product, capacity, segregation of the product (Ghosh et al. 2021). CE has an institutional background in creating a material supply chain, logistics, training, mixed raw material handling, reporting toward regulatory measures, and research and development. CE has many different holistic approaches to increasing the economy by maintaining the environmental sustainability strategic policy, managerial business trends, informational, technological, and organizational influence (Yadav et al., 2020), product stewardship (Jensen and Remmen, 2017), Eco-industrial parks (Winans et al. 2017). These give Information and communication technologies (Dwivedi et al. 2020) UN Sustainable Development Goals, coined the policy 2030, "zero-waste" byproduct synergy, oil recovery. The Sustainability Development Objectives of Circular economy approaches, in particular, will help to achieve Goal 12. In particular, circular economy practices will contribute to Goal 12 (Ghosh and Agamuthu, 2018) 4.0 manufacturing technologies in industries by integrating waste into landfills or incinerated (Ghosh 2020), Extended life cycle, Ecological balance Consumer behavior, Close loop system (Ethirajan et al. 2021) Product life cycle has a stakeholder satisfaction alsoplays a critical role in updating and transmitting client feedback (Jakhar et al. 2018). Robust analysis minimizes the environmental impacts of carbon emissions. Nonbiodegradable (Agrawal et al. 2021) economic, environmental, social, and technical perspective. Ninety-eight publications reclaim, recover, restore 90 billion tons by 2050 (Kakwani and Kalbar 2020) Biogas circular bio-economy (Kapoor et al. 2020), low-cost, end-to-end solid, extended producer responsibility (EPR), (Fiksel et al., 2021) industrial solid waste management (ISWM) (Mbuligwe, and Kaseva, 2006) These Review focus on the relation between CE and reliable waste management system "state-of-art technology" applications in the red category industry in India.

II. MATERIAL AND METHODS

The paper discusses 100 recent reviews, discusses the link between industrial solid waste management principles and the circular economy, and uses four variables to describe 1. General, 2. Technological concept, 3. Regulation policy, and 4. The report was concluded usingfour variables by SWOT analysis (Paes et al. 2019, Sodhi et al. 2020, Ławińska et al. 2022).

III. A SCENARIO OF CIRCULAR ECONOMY (CE)

By 2026, it is predicted that worldwide industrial solid waste management would be at 25 billion metric tons. (Wainaina et al.2020). The circular economy used to integrate the product at the End–of–life system is a combined form of business that has been maintained since the 1900s. Technology changes from solid waste evaluate different concepts, capacity, and usefulness from time to time. From 1970 to the 90s, lawmakers set up policies in various proportions for different manufacturing industries. Now the variables are other like the sage of carbon, hazardous waste material the procedure, the levy has set in its orientation, international institutional-like Environmental Protection Agency, Organisation for Economic Co-operation and Development, European Union introduced the Industrial Emissions Directive (IED-2010/75/EU) (Zeri 2013) introduced Best available technology and Circular economy (CE) United nation environmental Protection, Asia Pacific, Europe, and North America account for over 80 percent of the market share on a global scale can trade a product of debris or waste from the manufacturing industries (Kojima 2022). There are now classified technologies in the market to change solid /hazardous waste into a functional/recycled material. This regulatory approach cannot be practical in abating pollution due to solid waste has solids; semi-solids are a complex physical, chemical, biological in using of treatment techniques to decrease the inclusion of technology in the 1970s, EPA introduced the regulation with CE business combine technology in abatement by using end-of-pipe for hazardous/solid waste pollution control the existing technology offers three methods of treatment viz., Physical segregation, heavy metals and hydrocarbon treatment, Biological, and phytoremediation treatment technology (Arivoli et al., 2021a; Arivoli et al., 2021b). The physical

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techniques mainly help remove the solids through reduction and refuse (Varshney et al., 2022). At the same time, the processes include recycling, reuse, re-engineering, and modification (Al-khawaldaha et al., 2022).The quality of the product determines the type of treatment for use, pollution standards, and policies that can use the mode of final disposal of biological composting to reuse the co-processing product. In CE, The cost of pollution reduction depends on the level of pollution abated. It depends on the waste material like capacity, production, raw material usage, supply chain, demand and surplus, and material/ reverse logisticsmaintain a consistent business growth (Jha et al. 2022). As shown in figure 1, the concepts are explained in table 1.

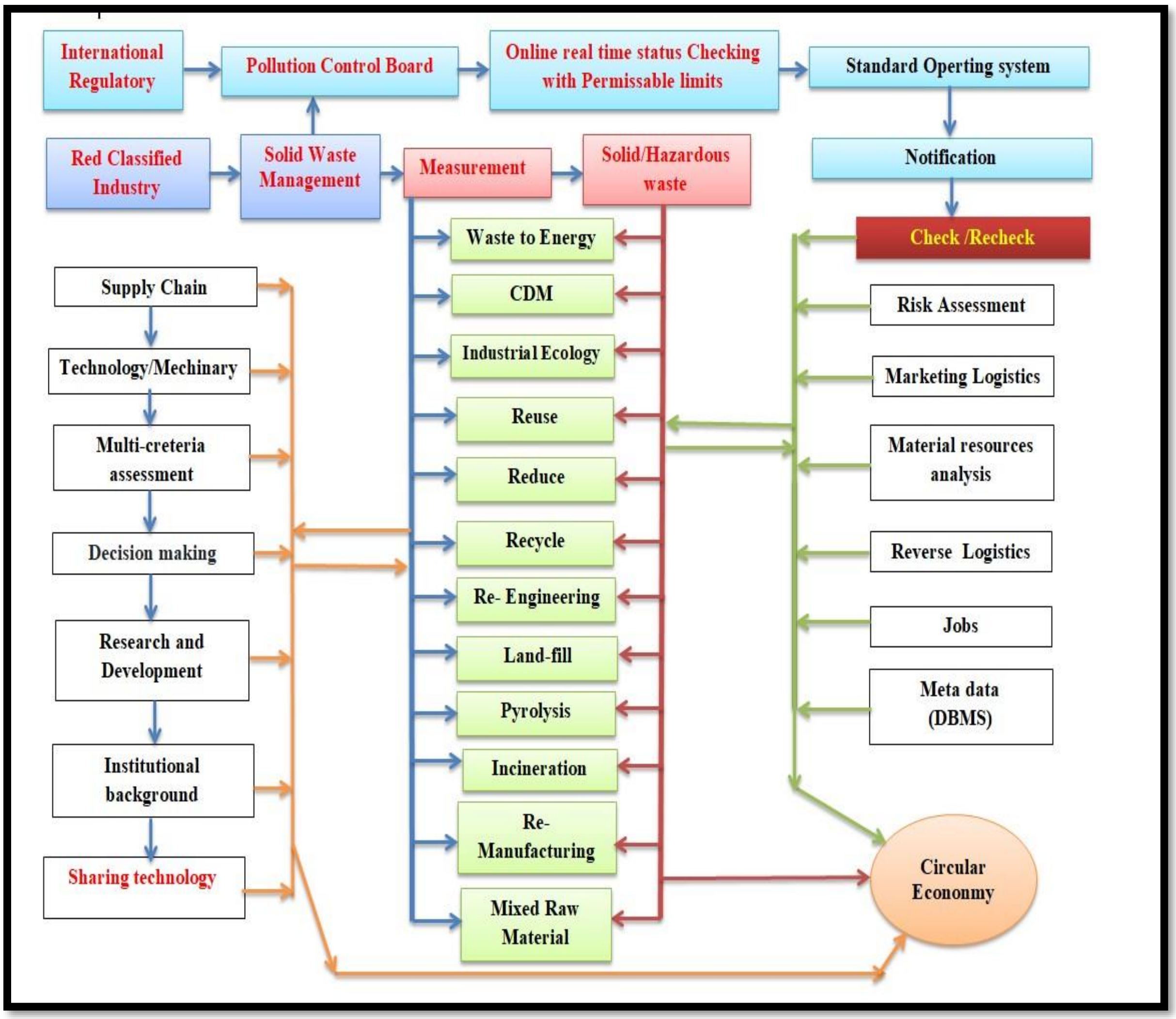

Figure 1. Shows the Regulation and technology assessment criteria with Circular economy

Table 1. Industrial solid waste Conceptual framework relating to Circular Economy (CE)

Industrial solid waste Concepts	Explanation of concepts given in figure 1.	Review and year
Circular economy	Creating waste to business opportunities in industry to break trade-off systems find a supply chain	Mancini et al. 2021
Solid waste	Non-hazardous waste can be recycled, reused, mixed with raw material usage, and used scrap for energy can be managed by CE.	Modak 2021
Hazardous waste	These cannot be reused, exposed to harmful waste, recycled, or used again due to non-biodegradable materials, including heavy metal and hydrocarbon; which can dump solid waste at safe disposal, likely to result in 12 to 14 percent of waste produced by the industries being combustible, highly explosive, toxicant, destructive, harmful, genotoxicity, destructive, contagious, or poisonous to fertility.	Ferronato and Torretta 2019
Reuse	Reuse can be done; a product can be recycled using specifications and demand for raw material.	Sohal et al. 2022
Recycle	Chain to create a market on specific SOP towards demand and opportunities to recycle the product.	Somani et al. 2021
Reduce	Reduction of raw material usage.	Naveen et al. 2022L
Re-engineering or Modification or closed-loop system	A recycled system reduces and reuses the production like co-processing; co-generation can be in demand for the production line.	Naveen et al. 2021g
Landfill	Landfills cannot reuse waste dumped in an anaerobic condition, but if it's an organic content, it can be used as a gas of 50 percent.	Kurniawan et al. 2021
Incineration/ Combustion	Wastes are burned in the presence of using excess oxygen (air) output is gas and ash.	Zhang et al. 2022b
Composting/ Anaerobic digestion	Organic and biodegradable material can be recycled and reused (Vrmi-composting)	Kabir and Kabir 2021
Pyrolysis/ gasification	Combustion is the chemical degradation of biodegradable materials in the absence of oxygen (O_2); it generates carbon monoxide, hydrogen, hydrocarbons (Carbon-di-oxide), CO_2, and N (Nitrogen).	Vershinina et al., 2022
Mixed raw material	Segregation of hazardous and non-hazardous material towards recycling and reusing the material.	Gupta et al., 2021
Industrial Ecology	Waste can be any material that can be recycled and reused as scrap material.	Naveen et al. 2021h
Waste- from energy	Co-processing recycle a co-generation plant with the self-sufficiency of industrial raw material.	Agnello et al. 2020f
Supply chain management	Recycling and reusing the co-processing has raw for business management, creating demand.	Agnello et al. 2020i

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Table 2. An Exploratory Research on a conceptual framework using SWOT analysis

Relation towards ISWM Concepts	Exploratory Analysis				
	S*	W*	O*	T*	Review
1. General					
Road Map	✓	✓	✓	✓	Verhoef et al. 2006, Chioatto and Sospiro 2022
Diffusion	✓	✓	✓	✓	Agnello et al. 2015a, Panwar and Niesten 2022
Supply chain Management	✓	✓	✓	X	Agnello et al. 2019b, Shyam et al. 2022
Market Value	✓	✓	✓	✓	Ezeudu et al. 2022
Finance	✓	✓	✓	X	Yadav et al. 2022
Demand	✓	✓	✓	✓	Webster 2021
Technology/Machinery	✓	✓	✓	X	Omoloso et al. 2021
Research and Development (Innovation)	✓	✓	✓	X	Dave 2021
Sharing of technology	✓	✓	✓	✓	Kanojia and Visvanathan 2021
Institutional background	✓	-	✓	✓	Bag et al. 2021
Reverse logistics	✓	✓	✓	✓	Kazancoglu et al. 2021
Material logistics	✓	X	✓	✓	Goulart et al. 2022
Public, private partnership	✓	X	✓	X	Patwa et al. 2021
2. Technological concepts					
Energy from Waste	✓	X	✓	✓	Pan et al. 2015, Sawhney 2021
Industrial Ecology or symbiosis	✓	✓	✓	✓	Lahane et al. 2021, Yu et al. 2021
Reuse	✓	✓	✓	✓	Sohal et al. 2022
Recycle	✓	✓	✓	✓	Agnello et al. 2022M
Re-design or modification	✓	✓	✓	✓	Kopnina 2021
Refuse	✓	X	X	✓	Ajwani-Ramchandani et al. 2021
Composting	✓	X	✓	X	Hazarika and Khwairakpam 2022.
Bio-technology	✓	X	X	X	Jain 2021
Exchanging waste for useful material	✓	X	X	X	Gupta et al., 2021
Land-fill or Dumping of Hazardous waste	✓	X	X	X	Gautam and Kumar 2021, de Azevedo et al. 2022
Pyrolysis	✓	✓	✓	✓	Felix et al. 2022
Incineration	✓	✓	✓	✓	Zhang et al., 2021
Mixed raw material	✓	X	✓	X	Viczek et al. 2020
Cleaner tech/Production	✓	✓	✓	✓	Agnello et al. 2019d, Naveen et al. 2022j
Integrated solid waste management system	✓	X	✓	X	Van et al. 2021
Life Cycle Assessment	✓	✓	✓	✓	Dahiya et al. 2020
Hazardous Risk Assessment	✓	✓	✓	✓	Kanwal et al., 2021
Material resources analysis	✓	✓	✓	✓	Puntillo et al. 2021
Standard Operating Procedure	✓	✓	✓	✓	Ghosh 2020
Multi-Criteria assessment	✓	✓	✓	✓	Vlachokostas et al., 2021
Stakeholder	✓	✓	✓	✓	Jakhar et al., 2019
3. Regulation and Policy					
International	✓	X	✓	X	Maalouf and Mavropoulos 2022
Local	✓	X	✓	X	Singh et al., 2018
Notification	✓	✓	✓	✓	Boloy et al. 2021
Financial Assistance from the Government	✓	X	✓	X	Agnello et al. 2019e, Priyadarshini and Abhilash 2020

4. Corporate sectors					
Mathematical Model technique Database Management System (Metadata)	✓	✓	✓	✓	Rathore and Sarmah 2020, Moktadir et al., 2020
Audit (Environmental, Energy, Quality)	✓	✓	✓	✓	Agnello et al. 2019c,
Organizational setup Learning /Training	✓	✓	✓	✓	Dantas et al. 2021
Surveillance	✓	X	✓	X	Velvizhi et al. 2020
Decision making	✓	X	✓	X	Ngan et al., 2019
Reporting	✓	✓	✓	✓	Munaro et al. 2020
Circular Economy	✓	✓	✓	✓	Naqvi et al. 2020
S*-Strength, W*- Weakness, O*- Opportunities, T*- Threats, ISWM*-Industrial solid waste management, ✓-Positive Tick points, X – negative points Nil					

Table 3 Findings of CE using SWOT analysis (Table 2.)

Strength	**Weakness**
G* - Updating and upgrading the new technology from global and local CE, signing several research and development bring new updates finding new entrepreneurship, supply chain material logistics private partnership and government subsidies. **TC*-** New entrepreneurship is good there many industries like most pollution with mixed raw material in the CE supply chain with material resources is essential. RP* - The government and private are working on an understanding. The government has given a lot of subsidies due to enriching the institutional background and has a lot of notification by 6R and energy from waste. C* - Audit should be reported by three consultants CPCB, research center, and a third party which suggests improving the quality of the production and output waste handling by surveillance; it helps to strengthen organizing improvement, review, and decision making in CE	G* -Updating, upgrading, service, and maintenance has been a prolonged process due to economic conditions, and also the supply chain is weak due to the presence of medium and small scale industries; large scale industries are very few, and they have their material logistics to recycle and reuse. TC*- Most polluting industries use refused materials to recycle and reuse. There is a trade-off concept in small and medium due to the cost factor. RP*- To enforce strict laws, shared or integrated solid waste management is set up. However, still, there is no quality assurance and well-managed officials, and the fund is very low for the SMEs.Large-scale industries are beneficial. C*- Cost is high for the SMEs, These cannot achieve targets due to international standards, Time delay, but large-scale industries are benefited.
Opportunities	**Threats**
G*- New Entrepreneurship, market value with raw material demand, the CE is a connecting business with a significant material supply chain. **TC*-** In India, energy is an essential part. Many co-generation plants' zero-waste of energy; composting is an important business, and the raw and mixed raw material is a critical concept like co-processing, etc. SMEs are large and diverse, so there will be a surplus and demand for raw material logistics. **RP*-** Give more subsidies and exemptions for cleaner technology usage and improve the quality of SMEs' products n SMEs.	**G*-** CE depends upon material logistics, supply, and production. SMEs refuse to upgrade the regulation policy due to financial constraints where large firms have their own logistics audit. **TC*-** SMEs have a CE practice of Integrated systems. Still, they concentrate on pyrolysis, incineration, and landfill, but large scale, the production of raw material usage has been increasing there is a demand in the supply chain of CE. **RP***-there is proper audit in the large

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C*-Audit can ensure review and a pattern of database management system it maintenance a reputation of the company in the CE.	scale industry, so they have in CE, but there is no adequate audit made in SMEs. **C*-** SMEs don't have a proper CE audit system due to time delay, and the cost of the CE audit is very high and slow in the process.
Note - 1. **G*** - General, 2.**TC***- Technological concepts, 3. **RP***-Regulation and Policy, 4. **C***- Corporate sectors**(Refer to table 2.).**	

IV.DISCUSSION AND EXPLANATION OF TABLE 2.

4.1 General Concepts

CE requires a Road map, Diffusion, supply chain, material logistics, institutional background, and private and government partnership because production input-output capacity is essential andplays a crucial role in defining the industry's consistency. These have different logic and math to the enterprises outsourcing the ability of the raw material is calculated by the CE with additional material consumption required with the regulation and subsides gained by the industries in technological up-gradation, solid waste database system, collaborative work for the sectors were large scale industries re benefited in India still small and medium enterprise have a financial difficult they cannot sustain in the CE industry.

4.2 Technological concepts

Most polluting 21 Industrial solid waste management systems (cutting-edge technology) relation towardsa circular economy (CE) Business in India. These technologies can be applied to the large, medium and small scale firms depending upon the raw material usage, output material capacity per day, and production quality Note -**SWM***- Solid waste managemen**t.**

1. **Aluminum smelter: SWM**- Fly ash, red mud granular furnace slag, glass-ceramic tile, Aluminium Sludge, and alumina hydrate by the Bayer chemical treatment process, Pre-bake, and Soderberg Technology Dumping using life cycle assessment. **Circular economy-** Recycle, Reuse, Reduce, Modification and Landfilling, **Advantage** -Reduce the content of Silicon, iron, titanium, calcium oxides, and caustic, Spent pot liners. Aluminum recycling is between 0.35 and 0.05 (Jing Wang et al., 2013, Allegrini et al., 2015, Mann et al., 2019, Nathália et al., 2021, Lukita et al. 2022).
2. **Cement: SWM**- Alternative fuel like oil and scrap metal, Co-processing (Lime and fly ash), modification in a kiln and Clinker, incineration, eco-precipitation with $CaCO_3$. XRD technique. **Circular economy** - Waste to energy, recycling, reuse, incineration. **Advantage -**12 to 15 percent of energy savings, iron and steel, cement, and Bricks industries (dry heat/ pre-heater / pre-calciner), Still in the research and development process, the efficacy of this technology, a real-scale test (3000000 kg per day)(Uson et al. 2013, Azad et al., 2015, Brankosavija and Mladena 2016, Pieper et al., 2020).
3. **Chlor alkali and asbestos-based industry: SWM**- Thermal, chemical hydro, and Mechanochemical treatments Membrane technology, Brine purification, Caustic filtration, Graphite and activated carbon treatment (Liquid to solid-state) Scrap diaphragms (semi- solid-state) Mining and processing. **Circular economy-** Reduce and Re-modification, Reduce the impurities, Asbestos waste recycle. **Advantage -** Sludge is reused; recycled Lead is 48.8 million tons (Jinhui et al., 2014, Thomas and O'Brien, 2017, Isabel et al., 2017, Valerio et al., 2019).
4. **Copper smelter: SWM**- Byproducts, slag, scales, and dust Basic oxygen furnace BOF slag, Blast furnace, high alkali chloride, reuse, Electric arc furnace EAF slag, Metallic wastes, Acids blast furnace, hydrochloride acid, iron oxides Decommissioning waste coke oven and coal storage (Wu et al., 2018, Mouna et al., 2020, Huibin et al., 2021).
5. **Distillery industry: SWM-**Composting (Vermicomposting), Bioearth compost, Potash recovery, Spent wash to press muds, Biogas production using sludge (Sulzers, Biothane Up-flow Anaerobic Sludge Blanket), hydrothermal carbonization Wastewater and solid waste

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streams generated by the brewing and distilling industry Bio-bed (UFB), biopaq process Anaerobic digestion, Fluidised Bed Reactors. **Circular economy-** Composting by recycling and reuse in agricultural waste has organic fertilizer, Recycle and reuse, waste to energy, **Advantage:** Bio-earth -38,000 MT/year, Press mud- 43,000 MT/ year, Converting 895 kg h^{-1} of wet spent grains, produces 257 kW of excess heat available to cover energy (Bijaya et al. 2008, Weber and Stadlbauer 2017, Manoj and Pravin 2018).

6. **Sugar Industry SWM-**Final molasses, Boiler ash, Bagasse (Cogeneration), Press mud or filter cake, recycling oil, Coal fly ash, and fly ash waste from the co-generation plant anaerobic digestion method Ignifluid, Composting (Vermicomposting), Cane cutting. **Circular economy** - waste-cum-energy, Reused Incineration, Fermentation, Combustion, gasification, Recycle and reuse. **Advantage** - Raw material in distillery industries Reused in sugar industries (3 MW to 4.5 MW per day depending upon the raw material capacity, Used in composting from the enhancement of bio-material, Biogas production, Ethanol synthesis, Co-generation plant, Organic fertilizer used in cane cutting, Waste cane cutting reused by the biotechnology (hardening method) (Shweta et al., 2010, Arif et al. 2017, Castaneda et al. 2018, Sahu, 2018, Ma et al. 2018, Fateme et al. 2020, Mohan et al. 2021).
7. **Dairy Industry: SWM**- Whey and milk cream, Membrane bioreactor, membrane filtration, Condensate recovery system, Pre-crystallization, Vermicomposting. **Circular economy -** Energy waste, Recycling Advantage - Biogas, Bio-methanation, production, and digestion. (Brazzale et al., 2019, Maria et al., 2022).
8. **Dyes and Dye- Intermediates: SWM-** Recovery of salts like sodium sulfite, sodium sulfate Effective washing of Gypsum sludge by Adsorption/Oxidation/Bleaching, Recovery of Mercury naphthalene from their sludge, Regeneration of spent carbon, Incineration of organic residue, Secured landfilling of Ash, ETP sludge **Circular economy -** Reuse, Recycle, Incineration, Landfilling Cement industries, Manufacture of pigment from iron sludge (Bhatia and devraj 2017, Sivaram and Barik 2019).
9. **Fertilizer: SWM** - Spent catalysts, Spent vanadium catalyst, Gypsum stacks phosphor gypsum, sulfuric and phosphoric acids, **Circular economy** - Recycle, NPK production (Superphosphates), Pyrite-roasting residues to the cement or steel-making industry (Canovas et al. 2017, Smol 2021).
10. **Food industry: SWM-** Anaerobic digestion (heat-moisture reaction) Vermi-composting, Bio-degradable method, Solid-state fermentation (SSF), **Circular economy**- Fermentation, Composting, Incineration to landfill (Ng et al. 2017).
11. **Textile processing:** SWM- Enzymatic removal, Inkjet printing, Sulphur dyestuffs, caustic soda from mercerization process, salt bath recovery system and Dye substitution, pad batch dyeing refused derived fuel (RDF) value for MSW, excluding metals, glass, and other inorganic waste, **Circular economy**- Reduce by fermentation, Reduce the ink to reuse, Caustic waste recovery, sludge composting waste-to-energy and integrated solid waste management. **Advantage**- 7.71 MJ/kg with a total energy potential of 6191.13 TJ or 1.72 TWh/year (Schonberger and Schafer, 2003; Sadef et al., 2016; Mia et al., 2019).
12. **Tannery Industry:** SWM- Process sludge skin, hide trimmings, liming /dehairing process/hide and skin, Fat extracted fleshing (wet-blue shavings) **Circular economy** -Pyrolsis, zero-waste approach Aerobic heating, Biochar, Phytoextraction, Bio-sequestration, Bacillus and methacrylic acid, Chemicals and mechanical methods, Acid treatment **Advantage-** Microbial, valorization, biopolymers Vegetable tanning, Thermo-chemical extraction method Anaerobic digestions, Bio-methanation process (Biogas), Phytoremediation (Basheer and Umesh 2018; Yoseph et al. 2020; Rigueto et al. 2020).
13. **Pulp and paper: SWM-** Pulp and paper with wood and board, Biomethanation (USB) Deinking, Pyrolysis, Dipolar Aromatic Solvent, Co-processing, Energy By Plasma Pyrolysis, Bituminous Road Construction, Condebelt Drying and boost drying Technology, Crude Oil By Agilyx Process, **Circular economy**- Combustion method, Fibres, fillers, coating clay,

calcium carbonate, Calcium carbonate, copper, micro-protein, Kaolin, ink, coating clay, recyclable fibers, wood, metal, Plastics, **Advantage** – Biogas production, generation heat, and power (Saadia and Ashfaq 2010; Bajpai 2015; Almonti et al. 2021).

14. **Pesticides: SWM**-Liquification and Recovery System, Incineration after distillation. Thermal decomposition, Caustic Scrubber, Recycle and reuse, Anaerobic + aerobic treatment, Chemical oxidation and recovery, incineration, solar evaporation. Detoxification of waste Advantage- heavy metals and hydrocarbons (Banerjee et al. 2019; Neksumi et al. 2021).
15. **Oil Refinery, Petroleum, and based product: SWM -** Distillate hydrodesulfurization, hydrocracker, fluid catalytic cracking, residue catalytic cracking, Sludge treatment (bioremediation), solvent extraction, reduce the leachability of toxic metals, desalter recover the hydrocarbons, gravity separators, and centrifuges (separation techniques) **Advantage-** Hydrofluoric acid alkylation produces neutralization sludges which may contain calcium fluoride, calcium fluoride, magnesium hydroxide, and magnesium carbonate (Bormotov et al. 2021).
16. **Pharmaceuticals:** Inorganic membrane reactors, separation methods, Solvent Minimization, Supercritical fluids, fermentation processes, nitrogen, phosphorus, and potassium content must be more significant than 5 percent, distillation, evaporation, decantation, centrifugation, and filtration, Process modification (Yu et al. 2020).
17. **Glass:** Ceramic Fiber, the Ultralite, the Vermiculite, Pre-Cast Pre-Fired (PCPF) (Maxim et al. 2018; Umarovna 2021; Hassel et al. 2021).
18. **Nuclear power plant:** SWM- Fluidized catalyst bed, mixed waste oxidation, membrane-based policy, cementation, bituminization, and plastic solidification), advanced oxidation processes (incineration, pyrolysis, acid boiling degradation) (Chandrappa and Das 2021).
19. **Sago Industry: SWM**- Starch material peels, **Circular economy** – Biomethanation, **Advantage**- Biogas production and digestion (Amin et al. 2019; Rasyid et al. 2020).
20. **Slaughterhouse: SWM**-Tissue, Blood, Organ, Hides excreta, **Circular economy** – Biomethanation, **Advantage**- Biogas production and digestion (Golbaz et al. 2017).
21. **Fruits and vegetable processing industry: SWM**- Pulping, **Circular economy** – Biomethanation, **Advantage**- Biogas production and digestion (Abdel and Mansour 2018).

4.3 Regulation for CE

The Solid/hazardous waste is differentiated into (88) types of dangerous waste (Management Handling and Trans-boundary Movement) Rules, 2008(Karthikeyan et al. 2018); the Central Pollution Control Board 58 industrial units located in primary potential scraps for co-processing in Cement / Thermal Power Plant / Iron & Steel / Sponge Iron industry (Neves et al. 2020) Resource Conservation and recovery act (RCRA) 3R, 4R, 5R, 6R, 7R,and the future 8R concept (Kolesnik and Merkulina 2021) can help industries to recover, repurpose, rethink, repair, refurbish, re-design, recycle, reduce, reuse, re-engineering, refuse, recharge and re-manufacture to a conventional system(Farmand 2022), like total industrial scarp material recoveries like Industrial ecology and alternative fuels and raw materials (AFR). Effective Management of HazardousCoprocessing and Co-incineration – Hazardous Waste Rules and Field Visit. These apply to small, medium, and large industries(Ghosh et al., 2022). Program objectives series (probes), Resource Recycling Series (RERES), Environmental Training Units (ETU) this has given 50 industrial guidelines Harazdous waste management series (HWMS), Common Hazardous Waste Storage, Treatment and Disposal Facilities (CHWSTDF), Treatment, Storage and Disposal Facilities (TSDF) Indian policy statement cleaner technology in SMEs, waste minimization circle (WMC), Demonstration in Small Industries for Reducing Waste (DESIRE)project, Comprehensive Industry Documents, Total quality management system (TQM) Environmental information system (ENVIS) Cleaner production (GCPC) in India(National Cleaner production centers creates database management system, with Technology Demonstration Centre for Conservation of Energy, Technology Absorption policy given by Companies act (Naveen et al., 2022j). This regulation is intended to ensure that the Financial Statements are accurate; conducting an audit towards the green rating project is a rating of industrial units on their carbon emission reduction and output footprint. One

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of the factors is cleaner technology. Energy conservation is a factor in Green Chemistry and Cleaner Technology like Plasma Pyrolysis Technology, 54 standard operating procedures, and notification now Bio-remediation of waste dumpsites is in action (Lang et al. 2022).

4.4 Background information on the organization, CE

The European Union Collaborative Environmental Awareness Campaign helps to encourage interaction between India and European countries in environmental field prevention. Two European education institutions were part of the project's community of educational institutes. Lund Institution's International Center of Industrial Environmental Indias Initiatives, Indian Institute of Technology in Mumbai, the Environmental Protection Training and Research Enforce at the University of Twenty in the Netherlands, Indian Institutes, Indian Institute of Technology in Bombay and India, and the Environmental Protection Research and Training Integrate in Hyderabad, India. The International Center of Industrial Environment Management at Lund Academic manages the program funded by the European Commission Council. The primary program objectives often provide academic achievement on preventive environmental management, establish study units in India for educating students and industry representatives, develop tools for application, including such datasets, publications, and handbooks, and create a twenty-eight sustained points transfer of knowledge in the field of PEM among India and European countries. Research organizations also include National Environmental Engineering Research Facility (Hazra 2022), the Central Leather Research Institute (CLRI), The Energy and Resources Institute (TERI), Refuse Derived Fuel (RDF), Extended Producer Responsibility, National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited laboratory, National Clean Energy Fund (NCEF), Inter-Ministerial Group Technical Expert Committee (TEC) from (Indian institute of technology) IIT-Delhi,Council of scientific and industrial research (CSIR) National Environmental Engineering research institute (NEERI), Environmental data bank, and the Center Buildings Research Facility. These introduced the website for Cleaner production in 2003 to link with MoEFCC's ENVIS environmental management system; the CPCB portal includes updated publishing of a monthly magazine. Provided 60 numbers as instructions. India has adopted the (Gujarat cleaner production center-Environmental information system (GCPC-ENVIS) (Naveen et al. 2022j) format connecting India's CE (Nandabalan et al. 2022). The Clean Technology Cell Division of India has a system called the Research and Development on Circular economies and waste Source Reduction Demonstration Project to promote the development and adoption by small and medium-sized businesses and collaboration sectors for pilot/demonstration projects. The Ministry has designated 24 industries for the latest tech development and technology. There are 18 ongoing projects, six new projects, and 25 completed projects in the plan. Small and medium-sized businesses.Government and private organizations are assisting CE in creating Memorandums of Understanding on training and supplying technical up-gradation, such as Terra green with the help of the Centre for Science and Environment, Pollution Control Board (PCB), Centre for Mining and Environment, Environment Protection Training and Research Institute, Indian Institute of Chemical Techs, and many others(Luthra et al. 2022). The Energy Research Facility, the Council for Science, Information, and the Environment, the National Environmental Engineering Research Institute, New tech, and Ministry of Power, State Pollution Control Board, and National Institute of Industrial Engineering) sponsored research projects (SPREAD), National Institute of Engineering Technology (NIET), Technology Demonstration Centre, and other industrial associations (Malik et al. 2022).

4.5 Energy conservation (co-generation) and finance are examples of circular economies.

The law (Energy conservation with Technology Absorption, under the rule to check over the financial/production input/output and require an audit to complete the circular economy process) has a policy that Every industry's certification process has been stringent (Highly polluting) The red industrial category has a regulatory approach that has been a rigorous and compulsory process for every enterprise's direction (Energy, recycling, co-generation, co-processing, and reusing) in India's large-medium scale sector. Supply chain

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management has strengthened capacity building for clean development with two ideas such as reverse and material logistics and the demand and surplus data-driven concept in deciding energy conservation initiatives. A hybrid approach database management system is created when a static policy of Perform-Achieve-Trade is used to envision a market-based mechanism under the Energy Efficiency system. It covers eight different industries, including thermal, power, aluminum, cement, fertilizer, iron, steel, distillery, sugar, paper, textiles, and Cholr-alkali (Naveen et al., 2022j), which generate solid waste for self-sufficient energy consumption bio-methanation and biogas power consumption of raw material co-processing systems. These industries account for India's principal energy logistics, which account for 40 percent of the country's total (Padamavathi et al., 2022). The goal is to utilize 6.68 million tonnes of oil recycling. Other sectors are also investing in solar/wind power supply, and according to The Department of Non-Conventional (Renewable), Energy Sources are connected to the grid (Singh and Singh 2022). Bio-power is further divided into Biomass energy, bagasse and Non-bagasse co-generation energy production, Bioenergy gasifier, combustion, sludge, other industrial debris, and small-scale hydropower (station capacity of 30 Mega Watts), and Thermal and Solar Photovoltaic-cells (Naveen et al. 2022h). Co-processing (sludge) can utilize the electricity supplied by such co-generation units to satisfy captive needs. dolochar as Alternative fuel and raw material (AFR) blended with coal in Atmospheric fluidized bed combustion(AFBC) boilers fuel (coal, oil) in AFBC and (Circulating fluidized bed combustion (CFBC) boilers and captive power plants, industrial process wastes like Brine sludge (Chlor-Alkali industries), Red mud, Spent Pot Liners (Aluminium industries), ISF slag, Jarosite (Zinc industries), Char Waste (Sponge iron industries), Spent Solvent (Pharma and Chemical industries), Paint sludge (Automobile & paint industries), Lime sludge (Paper, Carbide, Phospho-chalk, sugar sludge, soda ash, Chrome) (Papermill, Carbide plant, Soda ash plant), Effluent treatment plant (ETP sludge), RDF, Tank Bottom Sludge (Petroleum refineries, Waste oil recyclers), Steel slag (Steel industries) and Marble slurry waste to be explored for co-processing/ co-incineration. The excess power generated can be sent to the state's electrical system. Every small, medium, and large-scale industry are characterized by a condition on the input, raw material, production capacity, technological up-gradation, training facilities, and the annual mean rise in power generation (Kumar and Rao 2022; Naveen et al. 2022j). The International Development Program has contributed up to a ten percent share via nine demonstration projects in research and innovation, training, seminars, publications, and public affairs programs. India's Renewable Energy Development Project provided a global framework for renewable energy production to foreign funding organizations. The Asian Development Bank has financed a sugar-based co-generation project in India with a total capacity of over 4000 megawatts, which would generate around 5000 megawatts per year (Konde et al., 2021; Letti et al., 2022). India has licensed a bagasse/biomass/co-generation of the Cleaner Development Mechanism Project-based (carbon offsetting) and greenhouse gas program until 2030 (Deng et al. 2022). The US contributed Rs.1440 crores to the pilot program through the Environmental Protection Facility. A few options include international research and development, greenhouse gas emission reduction, the Project Bureau of Energy Conservation, and Electricity Regulatory Commissions (Dana et al. 2020). A plan is being developed to provide cooperative mills with creative finance. India wants to build 74 Gigawatts of By 2022, grid-connected renewable energy capacity will account for 15percent of total energy accounting for 4.1 percent of total energy performed with a sustainable audit to compensate for the energy industry's (Lal et al., 2022) Certification Emission Reductions (CER), Circulating Fluidized Bed Combustion, Electric Arc Furnace (EAF) (Gounder 2019) and Induction Furnace, "Sludge-Reagent-Product Technology" which provides a systematic approach to compare energy savings year after year (Aini et al., 2018). Energy management systems (EnMS) are accredited under ISO-50001 Commercial and government cooperation agencies, such as the green grading project, work in iron and steel, cement, thermal, glass, and other high-energy-intensive sectors lower emissions and production footprints (Naveen et al. 2022L).

V. CRITICAL REVIEW

Solid waste minimization with Economics of CE also involves choosing between regulatory approaches versus economic incentive/disincentive. It is essential to consider that the CE varies as the level of pollution decreases and the role of other variables like the level of output (or the size of the firm) and the impact of this cost behavior on the economy of the economy firm concerned. The choice question is between economics and technology. Has a vast difference in the reduction of industrial solid waste. Approaches may have to be decided on the grounds of the effectiveness, the relative cost society to the operating price of the instruments involved in the price functions for CE may differ between Hazardous/Solid waste management, but if one approach is less effective, the polluting firms will successfully try to avoid CE to the extent it could prevent costs.

VI. FUTURE SCOPE

The cost of CE is an important economic factor for every industry to maintain solid waste material with regulation (standard operating procedure). It gives information about the material logistics, place of recycling, subsides, private government partnership with Financial assistance have a twofold to improvise the abatement of technology in a step-by-step process and up-grading technology, time to time, training, instructional background, creation of new (MoU), research and development, notification, ratifying the regulation, amendment of new law the pollution control board (PCB) format given by economic perspective and monitoring frequently, towards industrial solid waste management (Database management system) to create a good business options fuzzy-Decision-Making, Pareto analysis (Chhimwal et al. 2021), big-data-driven circular economy end-of-life, Integration (Priyadarshini and Abhilash 2020) of Elimination and Choice Expressing Reality (Kumar et al. 2021), Green Consumerism, Sima pro-software (Yaduvanshi et al. 2016).

VII. CONCLUSION

CE policy within which is a step-wise increase involving different stages of treatment, such as primary and secondary stages of treatment, each set having its own additional capital cost, the marginal cost being almost constant within each step. Though the control authorities presently enforce pollution standards, industries must treat their Solid/hazardous/less energy usage/recycling products like total quality management. Which are otherwise harmful to society, the criteria generally used for this standard-setting are still not clear. An economist would think in terms of setting it at a point where the marginal cost of control equals the marginal benefit from averting the cost by pollution control technology, the question of the conventional or cleaner technology is suitable for efficiency, environmental sustainability, and social benefits and Towards to achieve using state of the art technology "Cradle to Cradle" situation.

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