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Research article

Life cycle analysis of the recycling process for construction & demolition waste management: A study of Noida, Uttar Pradesh

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ABSTRACT

Rapid urbanization in India has led to a boom in the construction sector, which uses a lot of natural resources, is the largest contributor to greenhouse emissions, and is a leading generator of Construction and Demolition (C&D) waste. The C&D waste is either disposed of at designated landfills or is illegally dumped in open places. Due to limitations on land availability, funding, transportation, and other factors, C&D waste management has been extremely difficult for Urban Local Bodies since the adoption of the C&D Waste Management Rules in 2016 (MoEFCC). The other challenges for managing C&D waste are its estimation and characterization, as well as the limited demand for products made from recycled C&D waste. The Anant Centre for Sustainability decided to evaluate the environmental influence of the C&D waste recycling process at an operational C&D waste recycling plant in Noida using the Life Cycle Analysis (LCA) approach. The LCA of the Noida plant revealed that transportation of the waste and minute particulates of the inert waste are the main contributors to environmental pollution. Further, the demand for the products produced from recycled C&D waste is not large enough to substantially reduce the use of natural resources in the production of construction materials. The study showed the need for further policy interventions and greater efficiency in the recycling facilities.

1. Introduction

About 30% of the waste produced worldwide is created by the construction industry. The environment is seriously threatened by C&D operations, which also have detrimental effects on resource depletion, increasing pollution, waste generation, and land degradation (Lu and Tam, 2013). In the range of 10% to 30% of all solid waste produced in each civilization is made up of C&D waste (Li and Zhang, 2013). According to Rao et al. (2007), a sizable amount of the C&D waste stream is inert and is recyclable or reusable with appropriate management.

Because there are regional and national differences in the manner waste is disposed of, estimating the content and generation of C&D waste is difficult. C&D waste composition also varies because steel, bricks, electrical wires, sanitary ware, etc. are sold to/ bought by secondary recyclers. Consequently, the remaining waste primarily comprises concrete debris and inert materials that are primarily responsible for air pollution, water pollution, and various kinds of toxicity. This waste is disposed of by onsite land-filling in low-lying areas, or by transporting it to designated dumping sites or illegally in low-lying areas. China is the largest producer of C&D waste followed by India (Akhtar and Sarmah, 2018).

According to Jain et al. (2018), it produces 100–400 MT of C&D waste annually, the majority of which comes from metropolitan areas. This amount is expected to increase as an additional 300 to 400 million people move into cities over the next several decades (UN DESA, 2018). By 2031, India's urban population is predicted to rise from 377 million in 2011 to 600 million, and about 70% of the country's projected building stock by 2030 has not yet been constructed (Made in India, 2016). The construction industry is predicted to increase at a rate of 7-8% over the next decade (Niti Aayog, 2018). The amount of construction waste produced is increasing as a result of all these operations (BMTPC, 2018).

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In India, managing C&D waste is a main challenge and the focusing on sustainable urbanization through a low-carbonisation process. In order to ensure nationwide enforcement, the Ministry of Environment, Forests, and Climate Change (MoEFCC) established C&D Waste Management Rules in 2016. These rules are further implemented and enforced by Urban Local Bodies (ULBs) in conjunction with city-level terms and conditions. The focus of ULBs is on the 3Rs (reduce, recycle, and reuse) approach of waste management to reduce greenhouse gas (GHG) emissions.

C&D waste is produced at every stage of a project's lifecycle and can be separated into four groups: (i) building new structures; (ii) remodelling or renovating existing structures; (iii) demolishing existing structures; and (iv) civil and infrastructural works (Peng et al., 1997; Wu et al., 2014). The kind and quantity of C&D waste are influenced by the size, construction method employed, and nature of the projects (residential or non-residential).

Building materials, debris, and rubble from the construction, remodelling, maintenance, and destruction of any civil structure are all considered C&D waste. Construction waste is an accumulated waste over a period of time. It's not generated at a single point in time. As construction is a stage-wise process waste material is also generated accordingly as per the use of virgin raw materials which is not having proper accountability. Maximum percentage of waste produced at the construction process's finishing stage; most waste produced by concrete is utilized during the core and shell stages of construction. Roughly 141 distinct types of materials are found in construction waste, according to a Godrej Properties Ltd. report (FFCT & Godrej Properties Ltd. 2023), of which 95 materials—including packaging and other materials—are already recycled and 46 materials have the potential to be recycled. However, only 14% of waste generated on the sites surveyed is recycled, while the remaining 86% is unaccounted for.

Compared to recycling mixed C&D waste, which involves materials like wood, plastics, glass, and iron, recycling mostly stony C&D waste will probably continue to have a different environmental impact. For example, recovering iron and wood is more beneficial to the environment than recovering stony materials (Dahlbo et al., 2015; Rosado et al., 2019; Simion et al., 2013).

Nearly 70% of waste in India is dumped illegally in open places and burnt seamlessly which creates negative impacts on our environment either way. According to Simion et al. (2013), recycling C&D waste produces CO_2 equivalent emissions seven times lower than crushed stone, and recycling materials from the C&D waste processing facility can prevent CO_2 equivalent emissions by nearly ten times (Coelho and Brito, 2013). The development of infrastructure for recycling C&D debris in India as well as in other developing nations is hindered by a number of factors, including a lack of awareness, insufficient legislation, lax enforcement and insignificant incentives (Hossain et al., 2016; Ram and Kalidindi, 2016). The most difficult task is estimating and quantifying C&D waste due to a lack of uniform methodology and accurate information.

1.1 Recycling of C&D Waste

Only 1 percent of India's C&D waste is recovered as well as recycled, per an investigation conducted by the CSE (Centre for Science and Environment). India produces 150 MT of C&D waste every year, as per the Building Material Promotion Council (BMTPC), however unofficial estimates place the amount closer to three or five times higher. About 1.3% of the total amount of C&D waste produced may be treated and recycled, with a recycling capacity of approximately 6,500 TPD. 53 cities were required under the C & D waste Rules to establish recycling facilities by 2017 in order to recover materials from the waste. As of mid-2023, there are only 13 cities with fewer than 20 operational processing plants. Cities do not all use the same methodology when it comes to estimating and classifying C&D waste.

The foundation of India's recycling business is the unorganized trash sector, which makes significant contributions to the circular economy and sustainability of the environment. The following are examples of informal stakeholders: waste go down owners, itinerant waste purchasers, waste go down pickers, informal collectors, and sellers of small-scale junk shops. Materials recovered from C&D waste, including wood, metals, glassware, and electrical wiring, are sold in the secondary market in India (Ram and Kalidindi, 2017; Sekhar et al., 2015). According to Islam et al., 2019; TIFAC, 2001; Zheng et al., 2017, the remaining fraction is primarily made up of concrete, sand, dust, and other particles, with a small number of metals incorporated in the concrete.

According to reports, India will need more than 600 to 700 MT of aggregates (BMTPC, 2018) and a comparable amount of sand (Ministry of Mines, 2018) annually. According to BMTPC (2018) and the Ministry of Mines (2018), there is a shortage of both minerals in India. Surprisingly, as sand shortages in several areas worsen, India is currently importing sand from foreign nations (Kukreti, 2018). The load on coarse and fine aggregates will climb significantly because residential constructions account for 67% of the weight of these aggregates (Devi and Palaniappan, 2014). Due to a lack of raw materials, fine aggregates are carried 70–100 km in cities like Bangalore (Reddy and Jagadish, 2003). Illegal mining happens across the nation as a means of avoiding high transportation costs. A prohibition on aggregate mining was imposed by several Indian states, which severely hampered primary infrastructure projects and necessitated the use of substitute building materials that include manufactured sand, or M-sand, which is derived from granite. M-sand is a recycled product and is very cost-effective compared to river sand. Tamil Nadu government's M-Sand Policy (2023), considered M-sand/crushed sand production as an alternative to river sand. Therefore, for India to continue urbanizing and increase resource efficiency, "recycling of C&D waste is essential. India's infrastructure for recycling C & D debris is still lacking (BMTPC, 2016, 2018). Presently operating recycling facilities in India employ a combination of dry and wet processing technological innovations to recover soil, fine aggregates (sand), and coarse aggregates. This results in a total recovery fraction of more than 95 percent of entering C&D waste by mass (ILFS, 2014; Mehta and Pandey, 2014).

Compared" to processing virgin materials, recycling of C & D debris has a substantial positive environmental "impact (Faleschini et al., 2016; Hossain et al., 2016; Rosado et al., 2017; Penteado and Rosado, 2016; Simion et al., 2013). Energy savings from employing recycled aggregates instead of virgin aggregates are 17% (Simion et al., 2013) and 50% (Hossain et al., 2016). As per Simion et al. (2013), recycling C&D waste produces CO_2 equivalent emissions seven times lower than crushed stone, and recycling materials from the C&D waste processing facility" can prevent CO_2 equivalent emissions by nearly ten times (Coelho and Brito 2013).

One major factor mentioned "in the degradation of the ecosystem is C&D waste. Its detrimental impacts on society involve land depletion, energy requirements and consumption, solid waste generation, gas and dust emissions, noise pollution, and the use of natural resources, specifically non-renewable resources. LCA examines the environmental effects and potential ripple effects from the acquisition of raw materials through the production, use, and disposal of a product" all the way from the 'waste' life cycle (when an item becomes worthless and is usually disposed of in the trash) to the grave (when value is restored by producing useable material or energy) (Finnveden, 1999).

Transporting C&D trash is a significant challenge for the value chain's operation, requiring an integrated method to move garbage from the point of origin to the landfill and ultimately to the recycling facility. Therefore, based on a review of secondary data, the Anant Centre for Sustainability, Anant National University, Gujarat, India decided to investigate the C&D waste recycling process at the fully operational C&D waste recycling plant in Noida to assess its environmental impact using the LCA approach. The major focus of the investigation is to comprehend the environmental influences of waste management practices. Generally, waste management studies examine the environmental impacts from the point of waste generation and its disposal to the point of material recycling and reuse.

1.2 Life Cycle Analysis (LCA)

Environmental problems like global warming and waste management are interrelated. LCA is regarded as one of the best tools with regard to sustainable management of waste. It is a standardized methodology that has been used for environmental evaluation of C&D waste globally which assists in further decision making. The LCA technique is frequently "employed in the research on C&D waste management (Bovea and Powell, 2016). It is a crucial tool for assessing the way environmentally friendly a product is by taking into account every stage of its life cycle, from raw material selection and production to building, operation, and disposal of the finished product, including recycling where appropriate. However, LCA studies are very limited in India as compared to European countries, the US, and China in reference to the management of C&D waste.

The LCA methodology, compliant" with ISO 14040 and ISO 14044, has been implemented to determine the environmental influences and benefits. The method's four phases are:

a) Outlining the purpose and parameters of the research,

b) Creating a model of the entire product life cycle that includes inputs and outputs from the environment. Life cycle inventory (LCI) is the term commonly used to describe this data-gathering activity.

c) Recognizing each input and output's environmental significance—a process known as life cycle effect evaluation, or LCIA

d) The study's interpretation and findings.

2. The Study: C&D Waste Recycling Plant Noida

As mentioned earlier, it is hard to estimate the exact quantity of C&D waste generated. Therefore, for this study, data was collected from secondary sources. Plant-based data was collected through field visits to the recycling plant, government offices, etc. to comprehend the whole C&D waste recycling processes and get data on various inputs and outputs/ products.

2.1 Objectives of the study

The objectives of the study conducted in Noida city of Uttar Pradesh are: To study the "prevalent C&D waste management strategies and practices in Noida city of Uttar Pradesh, to quantify the potential environmental impacts of C&D waste management in terms of its global warming contribution, to assess the scale of recycling C&D waste that" can replace virgin construction materials.

2.2 Materials and Methods

As mentioned earlier, it is hard to estimate the exact quantity of C&D waste generated. Therefore, for this study, data was collected from secondary sources. Plant-based data was collected through field visits to the recycling plant, government offices, etc. to comprehend the whole C&D waste recycling processes and get data on various inputs and outputs/ products. Life Cycle Analysis was conducted for this study using SimaPro - a software tool grounded in the robust Science of Life Cycle Analysis (LCA). The tool presents global warming as the highest impact. It is considered a preferred tool for creating ISO-compliant LCAs and has been used for assessing the C&D waste management process regarding its global warming contribution. SimaPro has many advantages, such as its association with many databases, flexibility, user-friendliness generation of transparent results, etc.

2.3 C&D Waste Recycling Plant Noida

Fig. 1 shows the Designated Dumping Sites in Noida. The UP Industrial Area Development Act of 1976 created the C&D Waste Recycling Plant Noida, an Uttar Pradesh special economic zone (SEZ) administered by the New Okhla Industrial Development Authority. Covering 203 km², it is a part of the National Capital Region and had 6, 42,381 people living there as of the 2011 Census (Census of India, 2011). The software, education, and mobile app development industries are concentrated in Noida, particularly in its Special Economic Zone (SEZ) area. As a result, Noida has the highest per capita income in Uttar Pradesh. The city's district administrative headquarters is in Greater Noida (380 sq. km., Population 2011 - 107,676), which was created as an extension to Noida. Noida is one of India's greenest cities with nearly 50% green cover. In the 2022 Swachh Survekshan ranking for cities with a population of 100,000 to 1,000,000, Noida was the fifth cleanest city in the country and the cleanest city in the Uttar Pradesh. The Uttar Pradesh State "Solid Waste Management Rules, 2016 were notified by the Urban Development Department of the Government of Uttar Pradesh subsequent to the announcement of the Solid Waste Management Rules, 2016. According to the Rules, every waste generator is required to store C&D waste separately when generated on their own premises, while the ULB should dispose of the separately stored C&D waste based on the C&D Waste Management Rules, 2016. At the project site, the bulk generators must sort the C&D waste into 4 distinct streams: concrete, soil, wood and plastics, and bricks and mortar. Prior" to the commencement of construction or demolition activities, every bulk waste generator, service provider, or their contractors are required to "submit a plan representing the necessities made for the collection as well as segregation of C&D waste of different streams, the C&D waste likely to be produced, and the period of project construction or" demolition. The plan outlines the steps that the service provider and bulk trash providers want to take to clean up the project site after it is finished.

Waste Collection Mechanism In 2017, the NOIDA authority conceived a project to deal with C&D waste and on 5 March 2019, entered into a PPP contract with Hyderabad-based Re-Sustainability and Recycling Private Limited (formerly known as Ramky Reclamation and Recycling Private Limited) for Around 400-450 TPD of C&D waste is recycled daily at the plant during operational time of 6 hours per day except for Sundays when electricity supply is not available due to load shedding. The volume of C&D waste is highest during the festive season, that is, from September to October. The lowest volume of waste is received from November to January due to National Green Tribunal restrictions. 15 workers are engaged in working on the plant. Of these, 5 are engaged in sorting the waste brought in from the dumping sites and 10 are engaged in the production of products. Contract labour is engaged in the production of pavers. 2 workers and 1 labourer stay on-site.

As per the concession agreement, NOIDA authority pays INR 495 per tonne for processing waste to ReSustainability. This includes INR 347 to be paid as transportation costs and INR 148.50 per tonne as processing fees to the agency. In the case of individuals, the cost will be borne by individual C&D waste generators. An individual, who is generating more than 20 tonnes of C&D waste every day would be allowed to avail the facility on payment of processing fees. It said that individuals may drop the waste at processing sites for recycling on payment of INR 148.50 per metric tonne.

The plant received about 18 truckloads of waste every day. Each truckload weighs about 20 tonnes. The trucks entering the plant are weighed at the weighbridge. Post the weighbridge the drivers of the truck sprinkle the waste in the truck with water till the time water starts dripping from the truck. This is done to prevent dust pollution on site. Post this, the waste is segregated (refer to the Fig. 2). The plant uses wet waste processing technology for which the 75,000 litres of water used for the plant per day is taken from the nearest STP facility. The washing water is recirculated only about 20-30% additional water is required for every reuse. Fig. 2 shows the Process flow of C&D Waste Recycling Facility, Noida

setting-up a C&D waste recycling plant at Noida. According to the contract, the firm set up an 800 TPD capacity plant (in two shifts) spread across five acres of land in Sector 80 with a capacity to process a minimum of 300 TPD. The cost of plant about INR 220 million is designed to handle, treat, transport, and collect C & D waste. The initial concession agreement is for 15 years during which time ReSustainability would pay an annual rent of INR 20,000 (@INR1/ Sqm). The plant was commissioned on 15 October 2020.

The recycling plant receives waste from 14 designated C&D waste dumping sites of approximately 400 to 500 Sqm. each. The collection centres are located within a 20 kms of the radius of the plant. Although waste generators are expected to dispose of their garbage at any approved disposal site, the plant authority bears the responsibility of transporting C&D waste from the collection sites to the processing facility. The truck drivers, who ferry the waste from the collection sites, are trained to identify the waste composition while picking up the waste from the site, in order to ensure that the composition of the waste to be processed does not have a higher soil content. If the truck drivers are not able to share the composition details, the waste is denied receipt in order to ensure that the truck drivers carry out the necessary due diligence at the collection site.

2.4 Waste composition

Composition of waste (excluding twin towers): Up to 3% municipal solid waste (MSW) mixed with C&D waste per day. Brick to Concrete (stone) received in either 60:40 or 70:30 ratio. The truck drivers, who ferry the waste from the collection sites, are trained to identify the waste composition while picking up the waste from the site. This is done to ensure that the composition of the waste to be processed does not have a higher soil content. Soil content clogs the grizzly filters and renders the line non-operational for at least 2-3 hours; time required for cleaning. If the truck drivers cannot share the composition details, the waste is denied receipt at the plant and the truck drivers are penalized for the same. This ensures that the truck drivers carry out the necessary due diligence at the collection site.

2.4.1 Waste received from Twin Tower demolition site (as on 3 November 2022)

The plant was set to receive 30,000 MT of demolition waste over a period of 3 months. By the end of October 2022, 6000 MTs of demolition waste had been received and processed.

The processed waste included recycled concrete aggregate (RCA) of very good quality that had the potential to be used in PCC (up to 25%), RCC (up to 20% only up to M25 grade), and lean concrete (100%). The recycled products have been supplied to Jewar Airport for on-site utilization. The plant was awaiting the go-ahead from the Noida authority to resume the waste processing from Twin Tower.

2.4.2 Plant Maintenance

The plant is operational for 8-9 hours a day. Out of this, 2-3 hours are devoted to greasing, cleaning, and general plant maintenance. Every 3 months, the plant is shut down for 2-3 days for equipment maintenance. All plant operators wear personal protective equipment while on the plant floor. They are trained to maintain sufficient distance while waste is being dumped into the plant.

Fig. 1 Designated Dumping Sites in Noida

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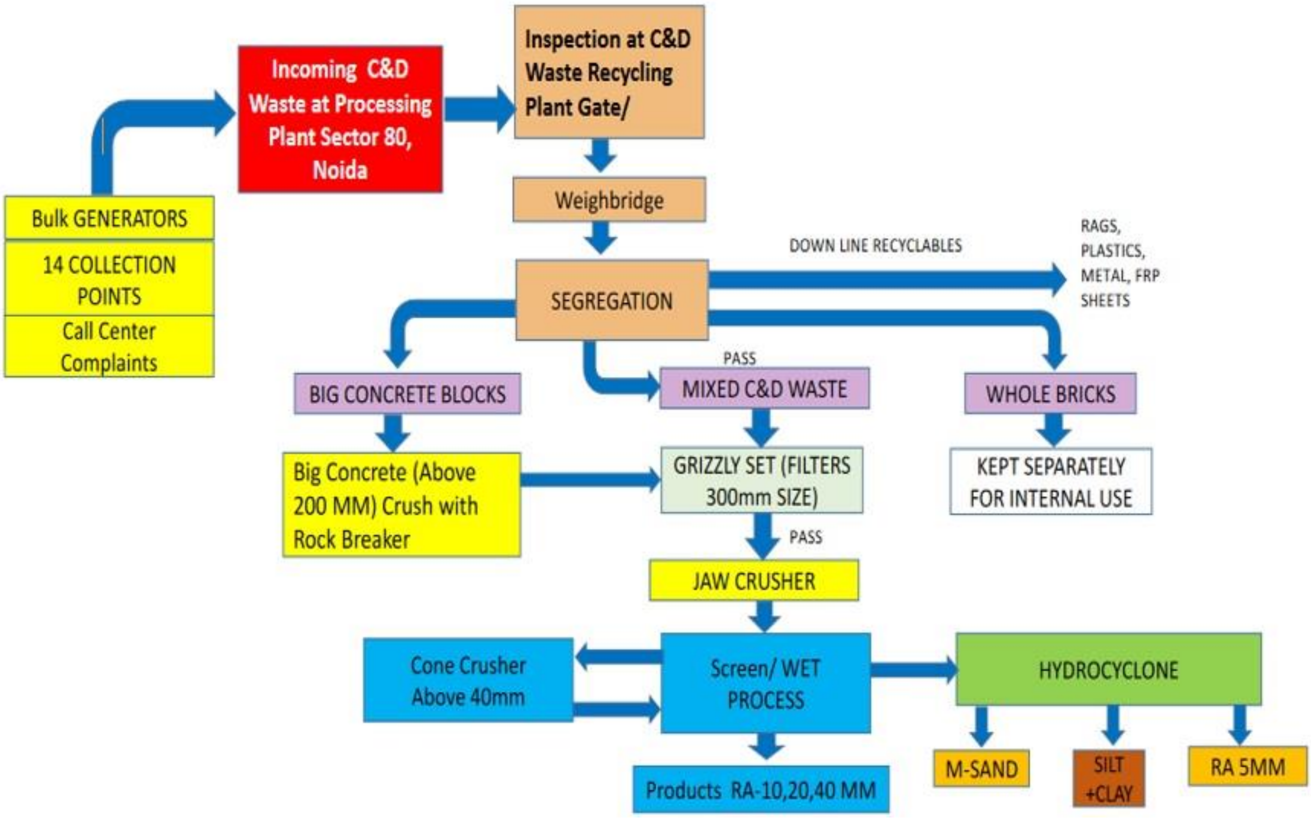

Fig. 2 Process flow of C&D Waste Recycling Facility, Noida

This is done to prevent dust inhalation. Also, the plant operators are given jaggery as a daily supplement to cleanse the air passage.

2.4.3 Use of Recycled Material

The recycled materials are sold for road construction, drain construction, and other related works. At present the coarse aggregate is sold for INR 250/tonne and fine recycled aggregates are sold for INR 750/tonne. ReSustainability also supplies recycled aggregates to RMC, construction companies, and other interested parties who wish to choose recycled products for civil and interior works. In addition to this, paver blocks of M25-M30 strength are manufactured on-site and sold through ReSustainability's dedicated marketing channels. Recycled waste is also provided to local manufacturers to produce concrete blocks which may be used as substitutes for bricks (non-structural purposes). Recycled C&D waste products are transported up to a distance of 60-100 km. (the farthest point is Jewar Airport). M-Sand, Dust, and Granular Sub-base are sold as construction material. Bricks, concrete blocks, pavement blocks, and curb stones are offered for sale on the open market. ReSustainability claims that, as the above figure illustrates, treating C&D waste can cut garbage going to landfills by 98%. Transportation costs, loading, and unloading charges are extra. No loading charges for aggregates and sand. Tiles and blocks are manufactured according to the orders received.

2.5 Life Cycle Inventory

The composition of waste consists of up to 3% of MSW mixed with C&D waste per day. Brick to Concrete (stone) received in either 60:40 or 70:30 ratio. Mixed C&D waste debris is sorted and then processed to attain output as M-Sand, dust and granular sub-base, pavement block, kerb stone, concrete block, bricks, and aggregates of 5,10,20, and 40 mm. Processing till aggregates is being considered for the present study.

In the present case, 1 tonne of waste is considered as the functional unit for the analysis. This facility was discovered to be consuming per day around 33KWH of electricity sourced from the Noida grid and 75,000 Litres of recycled water from the STP is managed by the same organization for processing of waste in the plant (considering gate-to-gate system boundary).

Atmospheric pollutant data is one of the significant requirements for LCA of C&D waste, which is not available inside the Noida processing plant. Taking that into account, we have collected air pollutant data from the nearest Air Quality Monitoring station, which is located very close to the Noida processing plant. Data is collected every day for a month period (27th January 2023 to 26th February 2023) and then the monthly average is taken into account. Four indicators such as Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), Particulate Matter (PM) size equal to or < 10 microns (PM_{10}), and PM with an aerodynamic diameter < or equal to 2.5microns ($PM_{2.5}$) have been collected and used for the "present analysis.

2.6 Life Cycle Impact Assessment (LCIA)

Because of the lack of C&D waste data for LCIA in Noida city, they were compared and analyzed in LCA using midpoint categories. For impact assessment in LCA, databases and factors are considered as important input and output variables in order to study its environmental impacts. In the present case, 18 environmental impacts are studied under LCIA. The outcome reveals that the Transportation of C&D waste is" believed to be a major contributing factor having an impact on air pollution, water pollution, and human health. Increased global warming, ozone formation, human health, stratospheric ozone depletion, ozone creation from fine particulate matter, terrestrial ecosystem acidification, shortage of fossil fuels, and marine eutrophication are all caused by it. Followed by Inert waste, that is, non-biodegradable material, which has a major influence on human health. The number of different types of toxicity has increased as a result of it, including ionizing radiation, human carcinogenic as well as non-carcinogenic toxicity, freshwater and marine ecotoxicity, land use, and scarcity of mineral resources.

High-voltage electricity is responsible for having a small impact on freshwater eutrophication and recycled aggregate has an impact on water consumption. Transportation of waste has the highest impact on environmental pollution followed by inert waste.

2.7 Interpretation of the Study/ Discussion

The interpretation phase evaluates the impact assessment and life cycle inventory analysis outcomes in the context of its predetermined scope and purpose of identifying various environmental characteristics. The present investigation's core data, which was gathered from the Noida processing plant to determine the life cycle of C&D waste, shows that, for every effect category, landfilling, sorting, and transportation contribute negatively to environmental pollution. C&D waste is potentially risky for environmental pollution as air pollution, water pollution, and to health of humans. Transportation distance of C&D waste and its inert substances, that is, non-biodegradable is majorly responsible for environmental pollution. To lessen its negative effects on the environment, the relevant municipal bodies must address the transportation distance of C&D waste. Fig. 3 shows the value addition after processing of C&D Waste of Noida.

3. Conclusion

India's C&D waste composition is different from that of Europe and the US because most of the recyclable wastes are purchased directly by informal and formal recyclers from the waste generators. Due to the uncertainties in estimating the quantum of C&D waste generated, authenticated data on C&D waste generation is not available. Land degradation, resource shortages, increasing pollution, and global warming are just a few of the negative effects of C&D waste that seriously threaten the ecosystem. Consequently, it has proven to be preferable to recycle C&D waste. Based on the LCA result, C&D waste is harmful to the environment, ecological resources, and human health.

Transportation of C&D waste and its inert nature is potentially risky for the environment as it is responsible for air pollution, water pollution, human health, increasing various kinds of toxicity, land use resource scarcity, etc.

Therefore, the transportation of C&D waste needs to be addressed by the concerned local bodies in order to decrease its environmental impact. Similarly, its inert waste is also another major responsible factor having major impacts on our environment which needs to be sorted probably by on-site segregation.

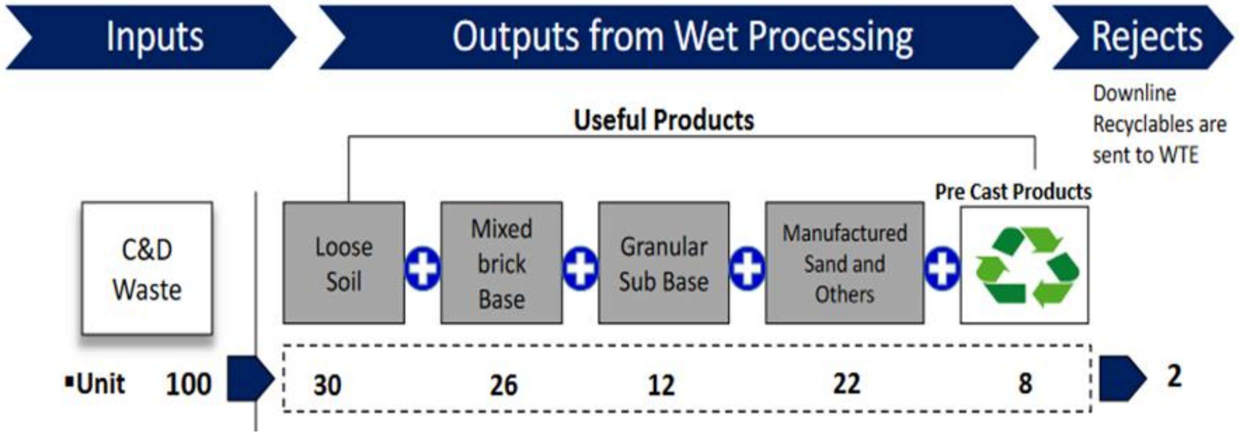

Figure 3: Value Addition after Processing of C&D Waste of Noida

Table 1: NOIDA – Summary of C&D Waste Recycled from 2018 to 2023

Financial Year	Collection & Transportation	Processing & Disposal		Sale		
	in Tons	in Tons	% of collected waste	in Tons	% of processed waste	Sale of Tiles in Pieces
2018-2019	0	0	0	0	0	0
2019-2020	109,773	0	0	0	0	0
2020-2021	70,122	40,313	57.49	24,096	59.77	0
2021-2022	174,996	131,542	75.17	114,985	87.41	88,215
2022-2023	146,734	131,739	89.78	142,019	107.80	178,297
1 April 2023 to 30 June 2024	36,478	36,358	99.67	37,659	103.58	32,804
Total	**538,103**	**339,952**	**63.18**	**318,759**	**93.77**	**299,316**

Source: Re Sustainability Reclamation and Recycling Private Ltd.

Table 2: NOIDA – Rates of Products made from C&D Waste

S.No.	Item Name	Thickness	Rates in INR + 18% GST		
			Grey	Red	Yellow
1	Zig Zag Tile	60 mm	11.00	12.00	12.00
2	Dumble Shape Tile	60 mm	11.50	12.50	12.50
3	Milano	60 mm	11.50	12.50	12.50
4	Zig Zag Tile	80 mm	12.50	13.50	13.50
5	Dumble Shape Tile	80 mm	12.50	13.50	13.50
6	Paver Block	80 mm	12.50	13.50	13.50
7	CC Block (400/200/100)	INR 32/piece			

Source: Re Sustainability Reclamation and Recycling Private Ltd.

Table 3: NOIDA – Rates of Materials from Recycled C&D Waste

S.No.	Item	Rate in INR + 5% GST Extra
1.	Recycled Aggregate 10mm	370
2.	Recycled Aggregate 20mm	350
3.	Recycled Aggregate 40mm	300
4.	Recycled Aggregate 5mm	750
5.	M-sand	850

Source: Re Sustainability Reclamation and Recycling Private Ltd.

Table 4: Data used for Transportation of C&D waste from Dumping Site to Processing plant

Variables	Input/ Output materials	Quantity per day	Units	Remarks
Fuel	**Input**	**86**	**KG**	**1 litre of diesel = 0.86 kg**
Truck type, capacity, and distance travelled	Input	81000	TKM	22 ton*270KM
Brick and masonry	Input	97.164179	TPD	As per the breakup of composition shared 31%
Sand, rock, gravel	Input	112.835820	TPD	36% is sand, rock, and Gravel but excluded Soil
Concrete blocks	Input	90	TPD	

Table 5: Data used for Manufacturing of Recycled Aggregates

Variables	Input/ Output materials	Quantity per day	Units	Remarks
Electricity	Input	33	KWH	NOIDA grid (coal-based)
Water	Input	75000	KG	Recycled water from STP
Recycled aggregates	Output	205.8	TPD	
Soil	Output	94.2	TPD	Considered as Inert also added residual to it
Atmospheric pollutants- PM 2.5	Output	87.18	micro gms	
Atmospheric pollutants- PM 10	Output	199.76	micro gms	
Atmospheric pollutants- NO2	Output	40	micro gms	Converted PPB to microgram
Atmospheric pollutants- SO2	Output	14	micro gms	Converted PPB to microgram

*Method: ReCiPe 2016 Midpoint (H) V1.07 / World (2010) H

*Indicator: Characterization

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Conflict of Interest

The authors declare that they have no conflict of interest.

Author's Contribution

Sharadbala Joshi: Original Draft, Methodology, Writing & Editing.

Dhaval Monani: Supervision, Monitoring.

Asima Sahu: Data Curation, Interpretation & writing.

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