CSIBER INTERNATIONAL JOURNAL OF ENVIRONMENT (CIJE)

Vol. 1, Issue No. 1, March 2024

Published By :

CSIBER Press, Central Library Building,
CSIBER Campus, University Road,
Kolhapur, (MS), INDIA, 416004

Find the Journal online at
https://www.siberindia.edu.in/journals
E-mail :editorcije@siberindia.edu.in

Published By:
CSIBER Press, Central Library Building
Chhatrapati Shahu Institute of Business Education & Research (CSIBER)
University Road, Kolhapur – 416004, Maharashtra, India

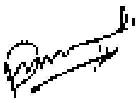
Contact No: +91-231-2535706 / 07
Website: www.siberindia.edu.in **Email: editorcije@siberindia.edu.in**

Editorial Note

CSIBER International Journal of Environment (CIJE) offers a venue where relevant interdisciplinary research, practice and case studies are recognized and evaluated. Increasingly, environmental sciences and management integrate many different scientific and professional disciplines. Thus the journal seeks to set a rigorous, credible standard for specifically interdisciplinary environmental research. CIJE is a multidisciplinary journal, publishing research on the pollution taking place in the world due to anthropogenic activities. CIJE welcomes submissions that explore environmental changes and their cause across the following disciplines like atmosphere and climate, biogeochemical dynamics, ecosystem restoration, environmental science, environmental economics & management, environmental informatics, remote sensing, environmental policy & governance, environmental systems engineering, freshwater science, interdisciplinary climate studies, land use dynamics, social-ecological urban systems, soil processes, toxicology, pollution and the environment, water and wastewater management, etc.

We invite authors to contribute original high-quality research on recent advancements and practices in Environment Management. We encourage theoretical, experimental (in the field or in the lab), and empirical contributions. The journal will continue to promote knowledge and publish outstanding quality of research so that everyone can benefit from it.

Er. D. S. Mali
Editor, CIJE



CSIBER International Journal of Environment (CIJE)

CONTENTS

Review of Plastic Waste Generation in Sangli-Miraj-Kupwad Municipal Corporation Area, Its Recycling Process and Benefits on Different Aspects of Environment

Chaitrali Govind Thombare
Student, Department of Environmental Management, CSIBER, Kolhapur, Maharashtra.
chaitralithombare577@gmail.com,

Abstract

Plastic is one of the most versatile innovations of our time. Plastic is usually a synthetic or semi-synthetic organic compound of very high molecular mass. It is the single use of plastics that has made it an ecological and environmental poison. Innovation is needed to drive social change and solve the biggest problem of our times which is Plastic Pollution. The paper studies the existing plastic waste management infrastructure in the Sangli-Miraj-Kupwad Municipal Corporation (SMKMC) area where we can consider 'Wastecart' as a waste management company. The study gives the quantity and types of plastic waste generated in different sectors of the SMKMC area. Furthermore, it evaluates the various plastic waste management strategies, including the entire process of plastic waste collection, segregation, and the further recycling process of each category. The study helps us in data analysis of waste generation to comprehensively understand the challenges faced by Wastecart in handling plastic waste. Plastic emits greenhouse gases right from extraction of raw materials, to manufacturing till its disposal. Hence, the paper also includes the analysis of carbon emissions curtailed due to waste segregation and recycling in the SMKMC area.

Keywords: Plastic Waste Management, Carbon Emissions of Plastic Waste, Categories of Plastic.

Introduction

Plastic is derived from cellulose. Plastic is a polymer chain. Many common groups of polymers are composed of hydrocarbons. These polymers are made up of small units bonded into long chains. Carbon makes up the backbone of the chain molecule and hydrogen atoms are bonded along the backbone. Even though the basic units of the polymer are carbon and hydrogen, other elements like oxygen, chlorine, fluorine, nitrogen, silicon, phosphorous, and sulfur are also involved.

Categories of Plastic Polymer plastics are divided into two distinct groups: thermoplastics and thermosets. The majority of the plastics are thermoplastics (around 80%) which can be heated and reformed again and again. This character allows for easy processing and facilitates recycling. On the other hand, thermostats (around 20%) cannot be remelted. Once these polymers are formed, reheating will cause the material to scorch. (Hosetti, B.B., 2006. Prospects and perspective of solid waste management. New Age International)

Plastic Waste in SMKMC Area

The plastic waste in the SMKMC area is divided into 5 categories viz. Polyethylene Terephthalate (PET), High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), Polypropylene Plastic (PP) and Multi-layered Packaging (MLP). PET takes around 5-10 years to decompose, HDPE takes around 100 years, LDPE takes 500-1000 years, PP takes 20-30 years while MLP takes 6 months to decompose. The PET is used for soft drinks, sports drinks, water, mouthwash catsup and salad dressing bottles, pickles, jelly, and jam jars. HDPE is used in products like milk, juice, cosmetics, cereal box liners, trash bags, etc. LDPE is used in squeezable bottles, dry cleaning, bread, and frozen food bags. PP is used in catsup bottles, yogurt containers, medicine bottles, etc. MLP is used in 3-5 gallon reusable water bottles, citrus juice bottles, etc.

Plastic Waste Management

Plastic waste management has become a pressing concern worldwide due to its harmful impact on the environment and public health. The problem of plastic waste is particularly serious in developing cities due to a lack of integrated solid waste management along with socio-economic, widespread poverty, and environmental injustice. Most of the generated waste plastics are neither collected nor properly disposed of causing littering and choking of gutters. The main problem with plastic recycling is, it is difficult to automate the sorting of the waste. Hence, recycling activities in India are demoted to the informal markets and are labor-intensive. Recycled plastic that contains impurities like labels, ink, prints, etc. can only be converted into low-value applications like pellets, benches, chairs, etc. A large number of aquatic animals, different mammals, birds, etc. are killed every year due to consumption of the plastic bags. These animals either eat these plastic bags leading to the choking of the digestive system or get entangled in them. Cows, donkeys, turtles, and fishes are particularly badly affected by plastic pollution. India produces more than 3.3 million MT of plastic every year which is increasing with every single day. Out of this, a total of 15 % of the plastic waste is recycled but the remaining 85% turns into waste which is either landfilled or dumped in oceans and water bodies. But as the population is also increasing the lands are becoming scarce and are overworked. (Sugata, D., Abhishek, C., Anuj, R., Singh, T.H., Kuldeep, D., Hasan, S.A. and Tanu, J., 2022). Plastic waste in India: overview, impact, and measures to mitigate: review. J Exp Biol Agric, 10(3), pp.456-473.

Petroleum was the main source of plastic manufacturing which does not easily degrade and remain in the land. The recovery of plastic to liquid oil through the pyrolysis process had great potential. The oil produced has a high calorific value comparable with commercial fuel. Pyrolytic oil and gas helps in reducing the dependency on fossil fuels. Plastic emits greenhouse gases right from extraction of raw materials to manufacturing to disposal. Also, it undergoes anaerobic decomposition when landfilled. Improper disposal methods further lead to emissions. 1.7 GT of greenhouse gases (GHG) emitted into the environment during the production and incineration stages of plastics causing a higher carbon footprint leading to climate change (Pathak, P., Sharma, S. and Ramakrishna, S., 2023. Circular transformation in plastic management lessens the carbon footprint of the plastic industry. Materials Today Sustainability, 22, p.100365). More than 500 million tons of CO_2 is produced by plastic annually. Nearly 0.253 Kg of carbon dioxide is emitted behind 1 Kg of plastic waste in landfills.

Literature Review

A brief review of the past studies related to Plastic waste Management.

Ola Eriksson, et al. (2009) in their article "**Plastic waste as a fuel – CO_2 - neutral or not?**" say that Municipal solid waste (MSW) is not only a societal problem addressed with environmental impact, it is also a resource that can be used for energy supply Recycling of plastic is in general environmentally favorable in comparison to landfill disposal or incineration. However, some plastic types are not possible to recycle and some plastic is of such low quality that it is not suitable for recycling. This paper focuses on the non-renewable and non-recyclable plastic in MSW. A CO_2 assessment has been made for non-recyclable plastic where incineration with energy recovery has been compared to landfill disposal in the assessment, consideration has been taken of alternative fuel in the incinerator, emissions from waste treatment, and avoided emissions from heat and power supply. For landfill disposal of plastic, the emissions of CO_2 amount to 253 g. The results suggest that efforts should be made to increase the recycling of plastics, direct incineration of plastics in places where they can be combusted with high efficiency and high electricity-to-heat ratios where it is replacing fossil fuels, and reconsider the present policies of avoiding landfill disposal of plastics.

Prosper Achaw Owusu, et al. (2017) in their article "**Reverse engineering of plastic waste into useful fuel products**" says that Thermal and catalytic reverse polymerization is an attractive method of handling plastic waste. In the experiment, a large temperature gradient was detected to exist between the reactor wall and the inside space of the reactor. It was found that fast vaporization during the cracking of HDPE in a continuous reactor lasted for about five minutes (between 35th and 40th minutes). Based on these findings, the presence of gas bubbles in the condenser can be used as an indicator to detect the beginning of the cracking process. The results showed that for a catalyst/polymer ratio of 1:10, liquid oils from HDPE, PP, and PS were low. The degradation temperature for maximum conversion was also low; and was observed at 300oC, 270oC, and 250oC for HDPE, PP, and PS, respectively. The presence of silica-alumina catalyst favored the formation of gaseous fractions.

The production of gaseous fractions increased from 17.2-20 wt% to 40.43-60 wt%. Thermal pyrolysis resulted in the highest yield of liquid oils for sample feed but at the highest degradation temperature. The degradation temperature observed during thermal pyrolysis of HDPE, PP, and PS were 450oC, 350oC, and 300oC, respectively. The yields of oil fractions in batch pyrolysis were significantly higher than the continuous and at a lower pyrolysis temperature. The characteristics of HDPE and PP pyrolytic sample oils are similar to conventional transportation fuel. However, further processing must be carried out (especially for PS oil) before it is used in diesel engines. Furthermore, for full implementation of this technology in developing cities, detailed sustainability assessment on economic feasibility, environmental impact, and social acceptability must be conducted

Boitumelo Makgabutlane, et al. (2022) in their article "**Plastic-fly ash waste composites reinforced with carbon nanotubes for sustainable building and construction applications: A review"** says that "the building and construction industry is the largest consumer of natural resources and contributes towards high volumes of carbon emission". To achieve sustainability in the industry, waste materials have been applied in construction composites such as bricks and cement/concrete mortar to reduce the dependency on non-renewable resources. Carbon nanotubes (CNTs), which are known to possess high mechanical strength have been identified as suitable filler materials to provide the desired strength to the final products such as bricks. The dispersion of the CNTs in the composite is at a finer scale, compared to conventional fillers. Thus, extremely low contents of CNTs can make a substantial difference in enhancing the properties of the composites. The waste-derived composites enhanced with CNTs are lightweight strong materials that can withstand harsh conditions of weather, fire, or earth tremors. Moreover, the environmental concerns on the release of CNTs from the composite are reviewed to ensure their sustainable application.

Sugata Datta, et al. (2022) in their article "**Plastic Waste in India: overview, impact, and Measures to Mitigate: Review**", say that With the expanding development, the usage of plastic for anthropogenic activities has expanded many folds and India alone generated around 3.3 million metric tonnes of plastic in the financial year 2019. 79 percent of the plastic generated worldwide enters our land, water, and environment as waste; part of it also enters our bodies through the food chain. The industry in India states that 60 percent of what is generated is recycled and we had assumed that we had solved the problem of plastic waste by recycling, or burying it in landfills. The review paper aimed to examine the major impact of plastic waste in India and how to reduce plastic consumption, considering measures such as phasing out or banning multi-layered plastics that cannot be recycled, contemplating renewable raw materials, promoting the use of bioplastics, incentivizing the recycling business, and making the rules and guidelines for Extended Producer Responsibility (EPR) simple and enforceable.

Pankaj Pathak, et al. (2023) in their article "**Circular Transformation in plastic management lessen the carbon footprint of the Plastic Industry**", says that around 400 Million tons of plastic waste has been generated so far and are projected to be doubled by 2040. Despite having plastic management rules worldwide, only 12% of plastic waste is recycled and reused, and the remaining ends cause pollution in every possible form. He says that 1.7 GT of greenhouse gasses (GHG) are released into the environment during the production and incineration stages of plastic, demonstrating a higher carbon footprint and leading to climate change. To overcome these issues it is mandatory to curtail single-use plastics from everyday use and enhance the recycling option in the plastic industry. The paper elaborates that there is **3.0 kg CO_2** emission per Kg of plastic. This paper advocates setting up stepping milestones for circular transformation in public industries that can reduce the carbon footprint by 25%.

Methodology

The waste cart collects the plastic waste from Sangli, Miraj, Kupwad, and Vishrambaug areas. Initially, awareness programs on plastic waste, its harmful effects on humans and the entire ecosystem, and different ways of plastic waste management are organized. These awareness programs are organized within schools, colleges, housing societies, different organizations, etc. Collection centers are set up in each area and representatives are appointed at each center. Collection drives are arranged every second Sunday. The waste collected during every collection drive is stored in the godowns which are further sorted and segregated by the laborers. This waste is sorted into 5 categories viz. Polyethylene Terephthalate (PET), High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), Polypropylene Plastic (PP), and Multi-layered Packaging (MLP). This segregated plastic waste is further sent to the recycling station in Malegaon where it undergoes different recycling processes.

- The PET bottles are first shredded in small pieces and then washed. They are further converted into polyester. Recycled PET is then used in tote bags, clothing, food and beverage containers, luggage, bottles, etc.
- HDPE is also initially shredded, washed, and then converted into small granules or pellets which are further molded into HDPE pipes. It is also used in products like liquid detergent, shampoo, motor oil bottles, recycling bins, floor tiles, dog houses, etc.
- The PP and LDPE on shredding and washing are converted to granules which are used for making low-quality materials like benches, tables, chairs, etc. Recycled PP is used in automobile battery cases, signal lights, battery cables, bicycle racks, oil funnels, brooms, brushes, etc. while recycled LDPE is used in shipping envelopes, garbage can liners, film and sheet, landscape timber, etc.
- The MLP on shredding is used for two purposes one is making threads and stripes and the other is using MLP for the pyrolysis process. At times LDPE is also utilized for pyrolysis

Results and Discussion

Below shown Table 1 below presents a breakdown of plastic waste by category for the period from January 2022 to December 2022. The plastic waste is categorized into different types, including PET, HDPE, LDPE, PP, and MLP. This table contains data on the quantities of plastic waste in each of these categories for the specified time frame, allowing for a comprehensive overview of plastic waste distribution.

As per below Table 1, the quantity of waste collected annually is 17,570 kg. As 1 kg of plastic waste emits 0.253 kg of CO_2 during its disposal as referenced by Eriksson, O (Energy & Environmental Science, 2(9), 907-914). Thus, 17570 kg of waste will emit around 4,445.21 kg of CO_2. As per the below calculations:

As 1 kg of plastic = 0.253 kg of CO_2 emissions

Hence, for 17,570 kg of plastic waste:

X kg of CO_2 emissions = 17,570 kg * 0.253 kg of CO_2/kg of plastic waste

X = 4,445.21 kg of CO_2 emissions

Table 1: Monthly Plastic Waste Distribution

Month	PET	HDPE	LDPE	PP	MLP	TOTAL
January	150	300	300	300	450	1500
February	108	216	264	252	360	1200
March	208	368	256	320	448	1600
April	129.2	342	304	349.6	395.2	1520
May	120.6	321.6	254.6	274.7	368.5	1340
June	143	300.3	286	343.2	357.5	1430
July	117.8	232.5	381.3	353.4	465	1550
August	174	290	275.5	304.5	406	1450
September	172.5	262.2	248.4	296.7	414	1380
October	129.6	340.2	324.1	333.7	492.4	1620
November	166.1	332.2	317.1	271.8	422.8	1510
December	147	323.4	294	338.1	367.5	1470
TOTAL(Kg)	1765.8	3628.4	3505	3737.7	4946.9	17570

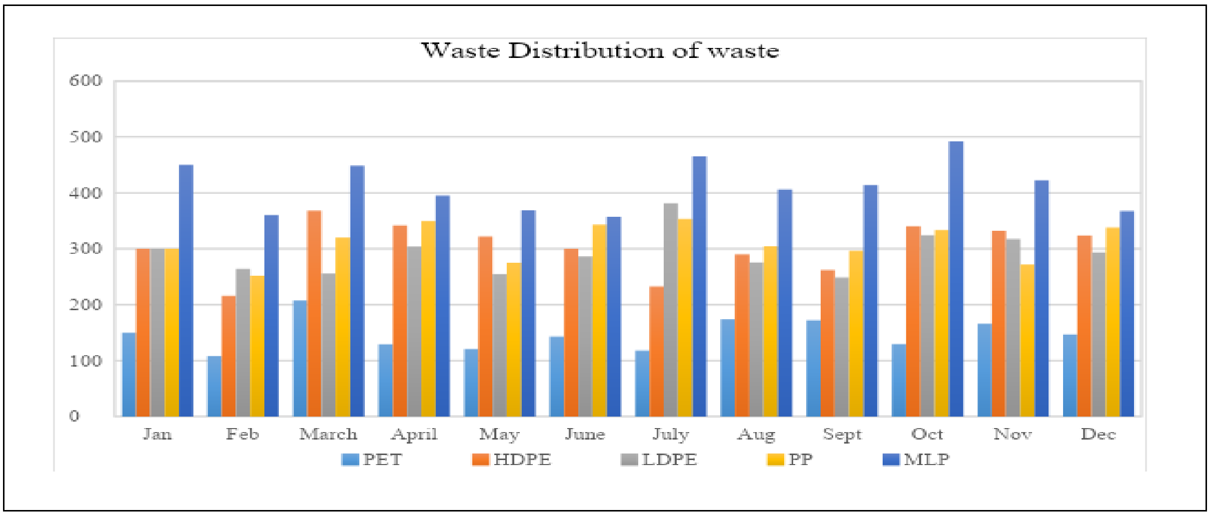


Figure 1: Bar Graph of the quantity of plastic waste

From Figure 1 we can observe that

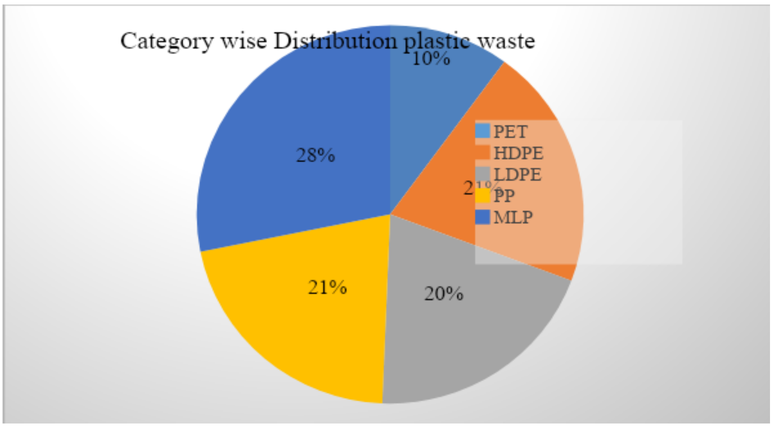
- The quantity of waste has increased in the Months of March and October in comparison to the previous month.
- PET was collected Minimum in the Month of February.
- HDPE was collected Maximum in March and Minimum in February.
- LDPE was collected Maximum in July and Minimum in September.
- PP was collected Maximum in July and Minimum in February.
- MLP was collected Maximum in October and Minimum in June.

Table 2: Distribution of 5 Types of Plastic

Sr. No.	**Type of Plastic Waste**	**Aggregate %**
1	PET	10.05
2	HDPE	20.65
3	LDPE	19.95
4	PP	21.20
5	MLP	28.15

Table 2 presents the cumulative percentage of each plastic waste category as a proportion of the total plastic waste generated in a single year. This table offers an overview of the relative distribution of plastic waste among different categories for that specific year.

Figure 2: Pie Chart of distribution of plastic waste



A total of around 1500 kg of plastic waste is generated monthly. Out of the total, PET contributes to 10.05% of the waste, HDPE forms 20.65%, LDPE forms 19.95%, PP is 21.20%, and MLP forms 28.15% of the total waste

Table 3: Differentiation of CO_2 Emissions

Month	Co_2 emission without recycling of plastic	Co_2 emission with recycling of plastic
January	4500	4120.5
February	3600	3296.4
March	4800	4395.2
April	4560	4175.4
May	4020	3680.98
June	4290	3928.21
July	4650	4257.8
August	4350	3983.1
September	4140	3790.8
October	4860	4450.1
November	4530	4147.9
December	4410	4038.1
Total	52710	48264.49

Table 3 depicts the amount of CO_2 emissions curtailed due to plastic waste management. Initially, the plastic waste would have emitted 52,710 kg of CO_2 right from its manufacturing to disposal. But, the CO_2 emissions are reduced by 4445.51 kg due to plastic waste management and recycling reducing the number of CO_2 Emissions to 48264.49 kg.

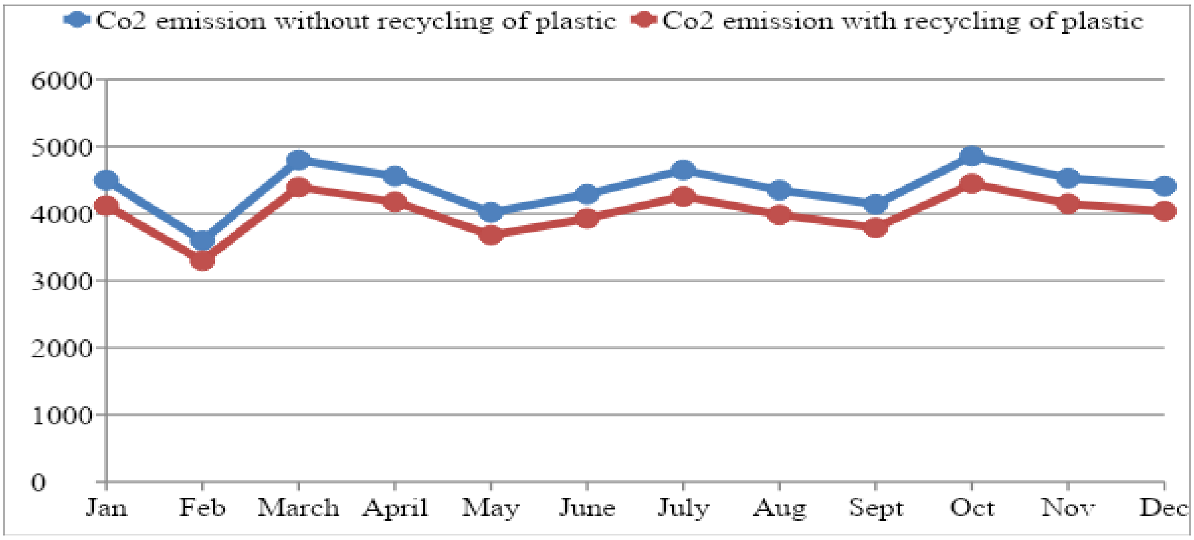


Figure 3: Comparison of Co_2 Emissions

In Figure 3 we can observe the reduction of CO_2 emissions which is shown by the red line in comparison with the estimated CO_2 emissions due to landfilling.

Suggestions:

1. Increase in Awareness

Public awareness about plastic waste management among the people should be increased. Awareness programs should be implemented for school-going children on a large scale and they should be made aware at an early stage. Social media initiatives should be implemented at a greater pace. Educational programs should be organized by the schools more often. Public awareness about the harmful effects of plastic waste on the entire mankind, animals, oceans, ecosystem should be created. Continuous awareness initiatives are essential to gradually and firmly implement eco-friendly habits and address the global waste problem effectively.

2. Considering the recycling and segregation of other categories

Other than the 5 categories, there are other types including Polyvinyl Chloride (PVC), Polystyrene (PS), and others. The other category is made up of more than one resin and is used in multilayer combinations.

3. Labour training

The main problem associated with plastic waste recycling is the unavailability of automation in waste sorting. Hence, it is primarily done by laborers. Laborers aren't trained. Sorting is done based on products, color, etc. Proper training programs must be arranged providing essential knowledge on identification, sorting, and categorisation based on its composition and recyclability. Training sessions should focus on categories of plastic waste, environmental impact awareness, and safety protocols to increase efficiency.

4. Usage of recycled plastic in new technologies

A. Clean hydrogen fuel:

Recycled plastic can be converted into hydrogen through the process of pyrolysis or gasification. As the plastic is made from hydrocarbons it can be broken down into hydrogen. This method provides us with a way of plastic recycling but also generates clean energy in the form of hydrogen which can be used in fuel cells or hydrogen-based technologies.

B. Road construction:

Plastic road technology can be used for using recycled plastic in road construction. The plastic waste consisting of bags, and bottles is shredded into small pieces and mixed with hot bitumen. The modified bitumen is then used to lay roads promoting a circular economy.

C. Carbon nanotubes:

Carbon nanotubes are produced by using recycled plastic through various methods like pyrolysis, carbon feedstock, and Chemical Vapour Deposition (CVD). Converting recycled plastic into carbon nanotubes is a sustainable way to repurpose the waste, conserving natural resources by reducing the need for raw carbon sources. Due to their properties of strength, sensitivity, and conductivity they are used in medical applications, sensors, nanotechnology, energy storage, etc.

Conclusion

The total quantity of waste collected from the Sangli-Miraj-Kupwad Municipal Corporation annually is around 17,570 kg. Out of the total, PET contributes to 10.05% of the waste, HDPE forms 20.65%, LDPE forms 19.95%, PP is 21.20%, and MLP forms 28.15% of the total waste. 17,570 kg of waste is collected annually from the Sangli-Miraj-Kupwad Municipal Corporation area. As 1 kg of plastic waste emits 0.253 kg of CO_2 during its disposal, 17570 kg of waste will emit around 4,445.21 kg of CO_2. Plastic waste management helps not only in carbon sequestration but also helps to achieve Plastic sequestration. It helps to secure used plastic out of industry and the environment into reusable building blocks made by some alterations. The raw materials used for plastic are crude oil, natural gas, and coal which are non-renewable. Hence, virgin plastic requires more energy and fuel. However recycling plastic waste helps to save these non-renewable resources along with avoiding landfilling and further land and groundwater pollution. Pyrolysis is the thermal degradation of plastic waste at different temperatures ranging from 300–900°C in the absence of oxygen. Pyrolysis is a technique that is used to convert plastic waste to liquid oil which can be used as a substitute for traditional fossil fuels like diesel, oil, etc. Catalytic pyrolysis using zeolite as a catalyst can be beneficial. The amount of CO_2 emissions is curtailed due to plastic waste management. Initially, the plastic waste would have emitted around 52,710 kg of CO_2 right from its manufacturing to disposal. But, the CO_2 emissions are reduced by 4445.51 kg behind 17,570 kg of plastic waste on its recycling and proper management i.e. CO_2 emissions are reduced up to 48,264.49 kg from 52,710 kg.

References:

Bhattacharya, R. R. N., Chandrasekhar, K., Roy, P., and Khan, A. (2018). Challenges and opportunities: plastic waste management in India.

Bura, N. (2019). An overview of plastic waste management in India. Waste Management and Resource Efficiency: Proceedings of 6th IconSWM 2016.

Eriksson, O., and Finnveden, G. (2009). Plastic waste as a fuel-CO2-neutral or not? Energy & Environmental Science, 2(9), pp. 907-914.

Gupta, S., Mohan, K., Prasad, R., Gupta, S., and Kansal, A. (1998). Solid waste management in India: options and opportunities. Resources, Conservation and Recycling, 24(2), pp.137-154.

Hosetti, B. B. (2006). Prospects and perspective of solid waste management. New Age International.

Makgabutlane, B., Maubane-Nkadimeng, M. S., Coville, N. J., and Mhlanga, S. D. (2022). Plastic-fly ash waste composites reinforced with carbon nanotubes for sustainable building and construction applications: A review. Results in Chemistry, 4, 100405.

Pathak, P., Sharma, S., and Ramakrishna, S. (2023). Circular transformation in plastic management lessens the carbon footprint of the plastic industry. Materials Today Sustainability, 22, 100365.

Rafey, A., and Siddiqui, F. Z. (2023). A review of plastic waste management in India– challenges and opportunities. International Journal of Environmental Analytical Chemistry, 103(16), pp. 3971-3987.

Sikka, P. (2007). Plastic waste management in India. Packaging India, 39(6), pp. 43.

Singh, P., and Sharma, V. P. (2016). Integrated plastic waste management: environmental and improved health approaches. Procedia Environmental Sciences, 35, pp. 692-700