Sustainable Development Goals 3.9: Environmental Pollution with Devices

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Abstract— **Sustainable Development Goals are designed to transform the world from life-changing 'zeros' to ambitious targets. SDGs have been built on the universal principle of 'leave no one behind'. The creativity, technology and financial resources from the society are essential to achieve the SDGs in every context. SDG 3.9 is concerned with the pollution of water, air and land. The environment is thereby polluted with more disposable then their usage. This disposable are hazardous to human health directly or indirectly and thereby increasing the mortality rate. World Health Organization stated that the landfilling with the disposable devices are mounting higher and polluting the environment. The need for solution is the use of reprocessed medical devices that was agreed by most of the hospital for various factors. Thereby, minimizing need of the single-use medical device, and protecting the environment. In this study, one will find the solutions for minimizing the emission of Carbon dioxide from the transportation, and the emission of Sulphur Dioxide and Nitrogen Oxide through Industrial waste and the need for carbon net zero.**

Keywords— **Greenhouse gas, Global Warming, Environment, Healthcare waste, SDG 3.9, Medical Devices**

I. INTRODUCTION

The study shows that every year, 8 million tons of plastic washes into the oceans, and seas harming aquatic species, land wildlife and natural ecosystems. Few tiny pieces of micro-plastics are found in the oceans, soil, and even the rainwater. Thereby, contaminating the food and drinking water which is leading to health hazards [1].

In the year 2019, the production of plastics summed almost around 368 million metric tons worldwide. The production of plastic, to a certain extent with energy intensive, requires 62 to 108 mega joules of energy per kilogram. The growth of plastic' market value continues with more usage [2]. The single use plastics are thrown to landfills. This landfill has chances to leak harmful pollutants and plastics on landfill top fly or pass into the nearby watershed polluting the water [3]. The best approach to curb single-use plastic pollution is to lessen plastic consumption or go for reusable plastic. Today's modern healthcare would not be possible without the plastic-use. Most innovative medical procedures are dependent on plastic, that allow artificial hip and knees to provide smooth working, trouble free joints. Added plastic packaging, with its exceptional barrier properties, light weight, low cost, durability, and transparency, is more ideal for medical applications [4].

Healthcare waste (HCW) generates lot of pollution with a great concern. Life cycle assessment (LCA) [5] quantifies the impact of product on environmental and public health, aids in materials selection and design or purchasing decisions [6, 7]. The scope of LCA involves material extraction and energy resources, manufacturing, packaging, transportation, and final disposal [8].

The public health risks associated with the components of HCW is a key concern to the entire world. The hazardous components of HCW rises physical, chemical, or microbiological risks to the society especially waste worker involved in waste collection and those involved in their handling, treatment and disposal. The physical injuries caused due to sharp MD disposal and also cause infectious health hazards [9]. WHO states action against on air pollutants caused by HCW [10], burning open HCW and incineration without any suitable pollution control exposes waste workers and the surrounding community to toxic contaminants in air emissions and ash [11].

In a report, company of MD stated that in U.S. more than 8,000 hospitals used regulated, reprocessed single-use MD, also minimizing astronomical waste transport fees in 2019 [12]. The medical device industry are transforming to a more circular economy that would improve the need of providing increasingly complex care with a low-emissions future [13]. Innovative Health's vice president of marketing and public affairs, Lars Thording suggests that it is better for single-use devices to be reprocessed, which can significantly add to the savings to the both the organization and environment. This process saves hospitals a significant amount of money, and is US Food and Drug Administration (FDA) approved when carried out correctly to specific guidelines. It's the hospital management and the committee that decides and stand firm to say 'no' when the manufacturer of MD push single-use expensive devices to them [14]. Further the survey includes that the single-use devices (SUD) prices are heftier than the reused equipment's in India and the risks involved in using the equipment labelled as "SUD" is a reprocessed one [15].

II. MEDICAL DEVICE PROCESS

New MD needs to go through a five phase process before its launch by the medical experts namely [16][17][18]. The medical manufacturer determines the MD's shelf –life span and it depends on the various factors. Based on the shelf-life, MD can be reused a restricted number of [19].

From the above survey, it proves that the Global health is significant for health care professionals to distinguish the magnitude of GHG emissions connected to health care [20]. In 2007 and 2008, US and Australia's health sector GHG emissions totaled 547 million and 553 million metric tons of CO2 equivalents, respectively, a greater impact to climate change [21]. Greenhouse gas (GHG) emission in the packaging sector is found to more in either single-use or reusable devices [22]. Hereby, GHG emission by healthcare leads to global warming and climate change. Reprocessing devices cut global warming impact to minimum [23].

III. DISCUSSION AND RESULTS

The air pollution started in India in the year 1990, due to the increase of Industrial Growth and also Health Care Centers. The year 1990 has seen tremendous change in Information Technology age with the entire IT hub revolutionizing the states of Bangalore, Pune and Hyderabad. It improved the socioeconomic growth in the country and also the pollution causing diseases in humans, animals and plants. It disturbs the entire ecosystem with global warming; this slight increase in temperature causes a remarkable transformation of the planet with carbon zero.

Out of eight major pollutants to calculate Air Quality Index (AQI), one needs minimum three pollutants. Among them, one needs to have PM2.5 or PM10 for calculating AQI.

1. CONTROL OF POLLUTION

OZONE

It's in the hand of every citizen to reduce the ozone levels by conserving energy at work or home; there are ample ways to reduce it. One can reduce through walking, cycling or use maximum public transport to reduce gasoline-fuel, regular check on the motor engine and tires too. The various study concludes that ground level ozone measured at various stations exceed the threshold limit. This ground level ozone is an ultimate to health hazard – leading to respiratory and cardiovascular diseases [24]. A solution to minimize CO2 from transportation, this system is followed in most aboard countries.

CARBONDIOXIDE

The figure 1 shows the gradual increase in atmospheric concentration of CO2 emission from the year 2000 to 2013 whereas the burning of fossil fuel emission is comparatively higher than CO2. CO2 emission shows the highest contribution (figure 2) from airways (33%) followed by cars passenger (25%) and roads freight (23%) for the year 2020.

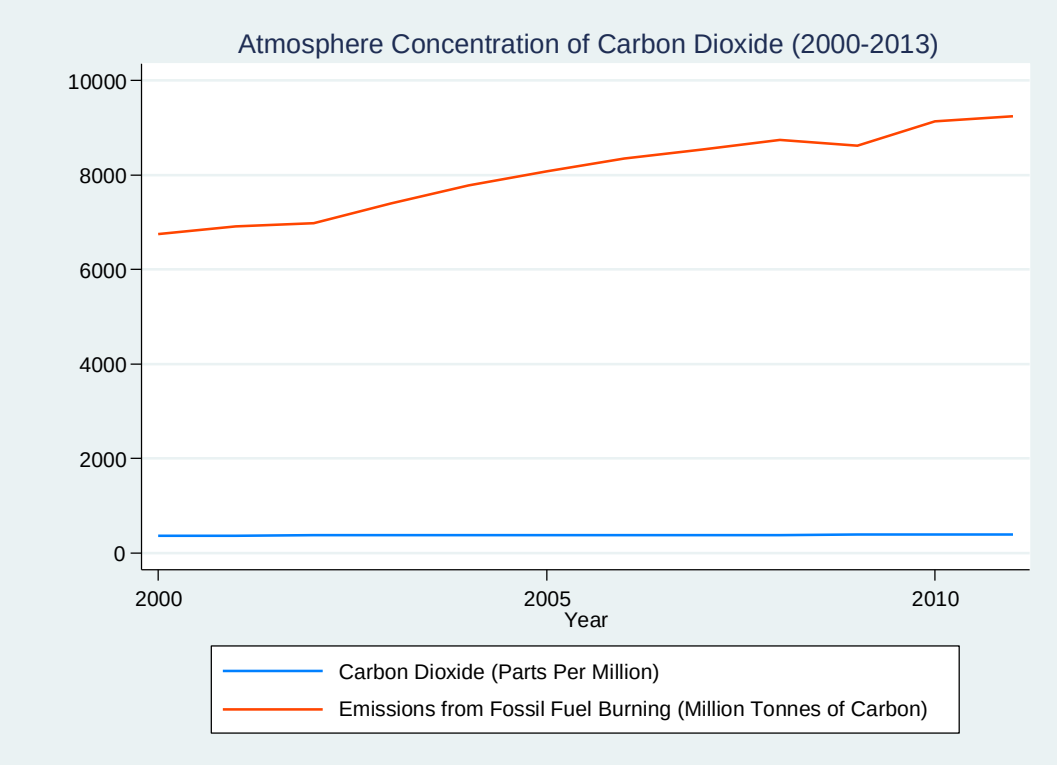

Figure 1. Atmospheric concentrations of CO2

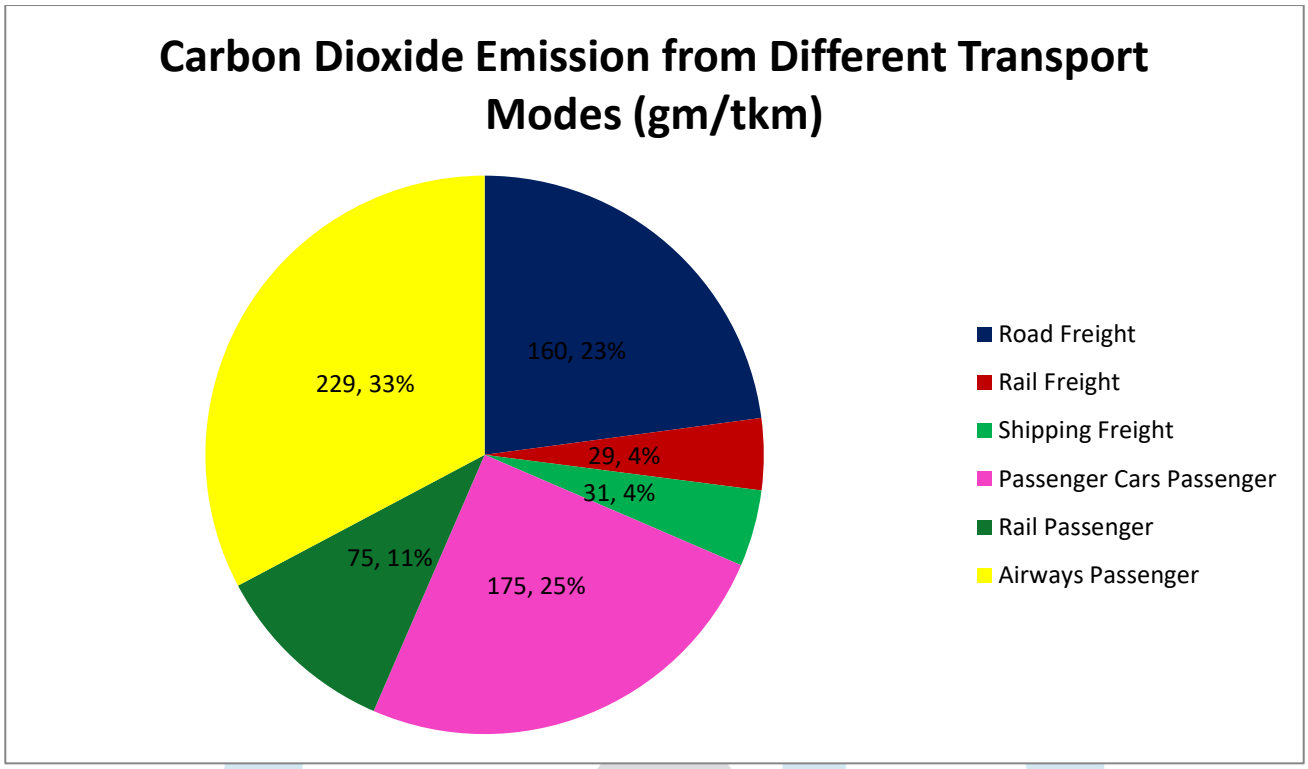

Figure 2. CO2 emission by the transport

NITROGEN DIOXIDE

The higher levels of NO2 cause damage to the human respiratory tract, and increase the severity of respiratory infections and asthma. Chronic lung disease is prone to long-term exposure to high levels of nitrogen dioxide. The figure 3 shows the relationship of Cumulative of Chronic Obstructive Pulmonary Disease and Respiratory Mortality with Sulfur and NO2 Concentration. Table 1 represents the emissions of SO2, CO2 and NO2 per day for the year 2016 to 2019 from thermal power plants estimation provided by CPCB [25].

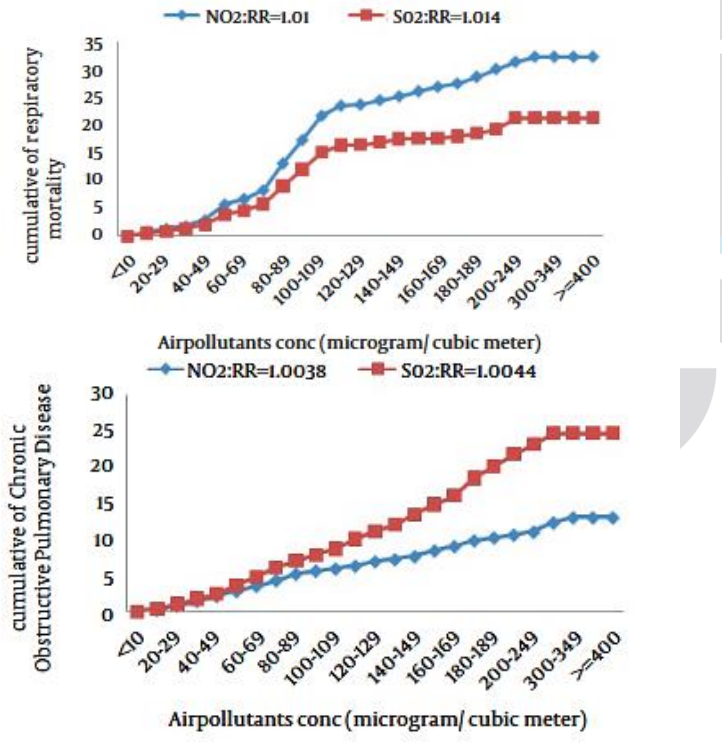

Figure 3. Relationship of respiratory mortality and chronic obstructive pulmonary disease with SO2 and NO2

One solution would be that planting or shifting nitrogen plant for the production of O2 to a nearby hospital or, in case it is not feasible to shift the plant. It can be used at on-site production of O2 that can be transported to hospital through cylinders.

Table 1. Pollutants- SO2, CO2 and NO2 from the year 2016 to 2019

Gaseous Pollutants Per capita per day			
Year	SO2 (Kg)	CO2 (Ton)	NO2 (Kg)
2016	0.0203	0.0018	0.0209
2017	0.0211	0.0019	0.0217
2018	0.0217	0.0020	0.0223
2019	0.0214	0.0021	0.0219

2. IMPLEMENTATION OF NEURAL NETWORKS

Considering all the various factors as inputs and training these factors using neural network gives tremendous results for predicting the output. The step-by-step procedure is shown in the figure 4. The *n* inputs values are denoted by $x_1, x_2, \ldots, x_n$ in figure 5. The inputs are given the weights as $w_1, w_2, .., w_n$. The input values are then multiplied by the weight and summed as in the equation 1.

$$s = w_1 x_1 + w_2 x_2 + ... + w_n x_n = \sum_{i=1}^{n} w_i x_i$$

---------- eq (1).

The output function *z* of the weighted sum is known as activation function, $z = f(s) + b$, where *b* is known as bias parameter (Eq. (2)) [26].

$$z = b + \sum_{i=1}^{n} w_i x_i$$

---------- eq(2)

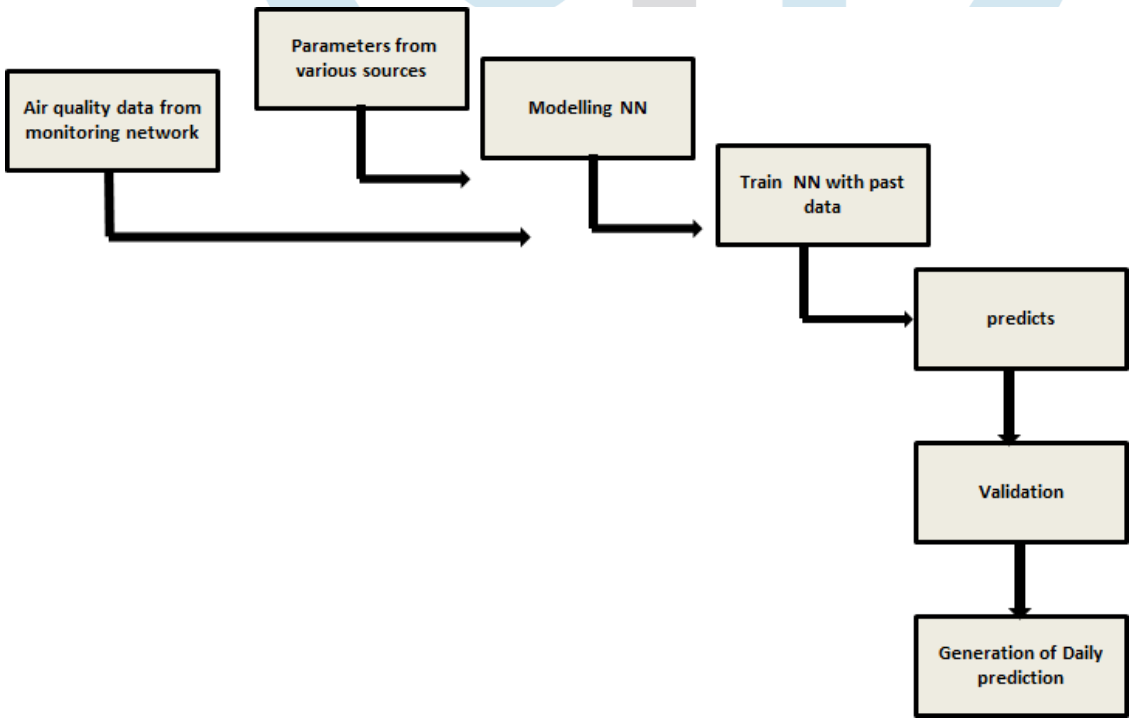

Figure 4. Step by step procedure for ANN

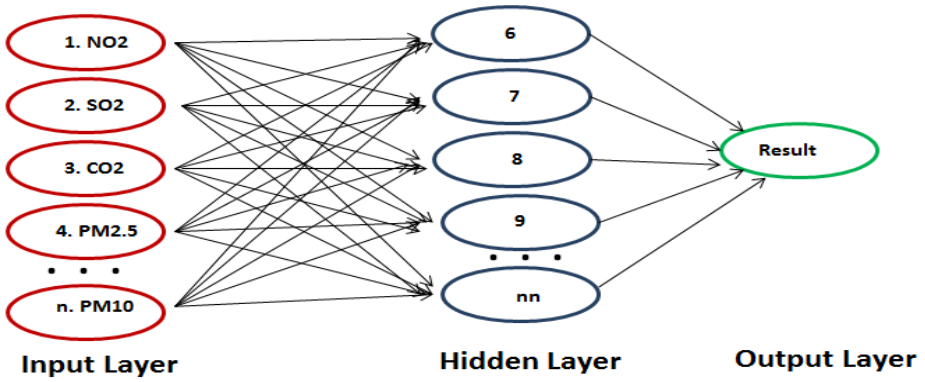

Figure 5. Neural Network model

Figure 6 depicts the NOx and CO emissions are higher from the vehicle exhaust followed by PM and SO2. The intensity of the emissions in the year 2010 (top) and 2030 (bottom) and beyond is expected to increase the surrounding the urban centers due to the growing passenger travel demand and along the highways due to the growing freight movement between and to the cities.

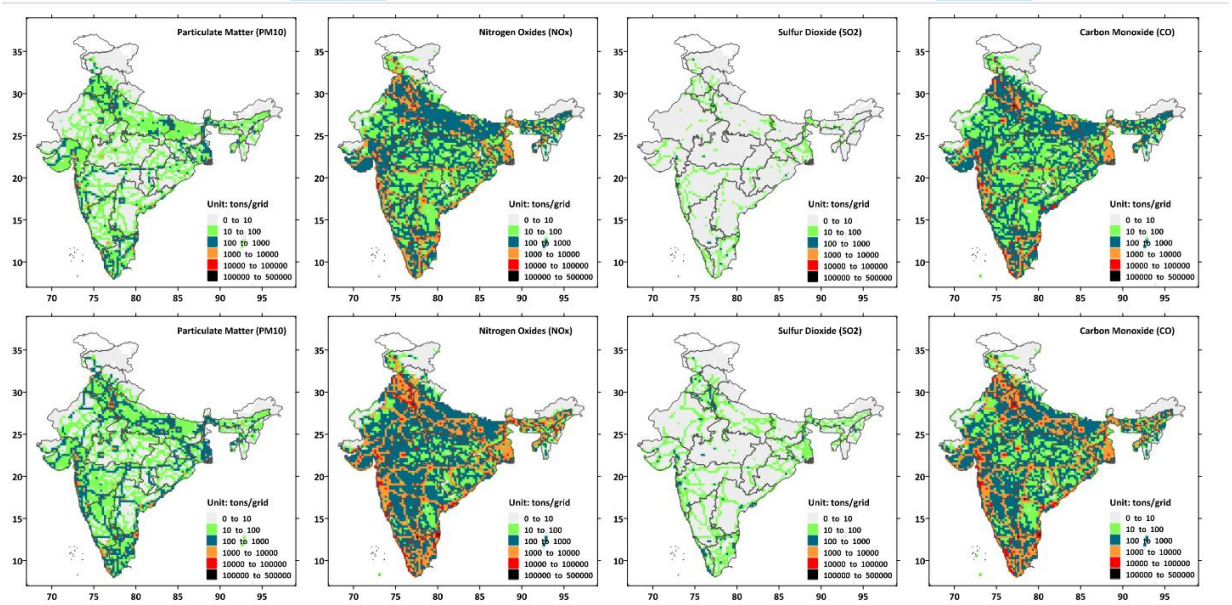

Figure 6. The emission of NO2, SO2 and CO for the year 2010 and 2030

3. ARTIFICIAL INTELLIGENCE FOR MEDICAL DEVICES

Artificial intelligence (AI) and machine learning (ML) technologies are transforming health care centers by deriving new insights from the huge amount of data generated during the health care delivery every day [27]. Medical device manufacturers are using these technologies to innovate their products to better support health care providers and improve patient care. One of the significance of AI/ML in software resides in its ability to learn from real-world use and experience, and its capability to improve its performance. Thereby, AI is shaping an increasing every sector; and thus, AI helps to improve the health of ecosystems [28].

Software as a Medical Device (SaMD), used for one or more medical purposes that perform certain solution without being part of a hardware MD [29]. Most of the health care decisions are increasing relying on information provided by SaMD. The role of AI/ML algorithms in process of MD development, an opening to lot of doors and making complex analysis more possible in a wide range of applications. A great rule of thumb (Dr. Andrew Ng, Stanford) shapes anything a human can "think through" in a second is a possible candidate for AI or machine learning [30].

Types of AI applications are currently used in development in the MD sector at industry-leading firms [31]. The software change will be guidance assistance for industry and manufacturer in determining the medical device and obtain FDA clearance of a new product [32].

AI/ML algorithms namely Convolution Neural Network, support vector machine and Bayes Naïve Algorithms can be used to train and identify the life span/ shelf life of any reprocessed medical device or identify regarding the pollution. Thus, AI/ML algorithms ensure the data integrity [33] and consistent of approval [34] of the MD reprocessing. To achieve the successful path and to improve global access to appropriate MD, one requires four 4 A's—Availability, Accessibility, Appropriateness, and Affordability. This will lead to global achievement for any reprocessing devices [35]. Thus, AI/ML algorithms will indirectly

reduce the environmental pollutant by initiative of reusable devices and automates the whole process without the interference of any human. These algorithms can save the manual process such as during any pandemic time and the need for the devices is more.

4. BIO-MEDICAL WASTE IN INDIA

According to the Central Pollution Control Board (CPCB), India generated bio-medical waste (BMW) over 18,000 tonnes of COVID-19 between June and September 2019. It includes PPE, gloves, masks, head cover, plastic coverall, hazmet suit. In June 2019, India generated BMW of 3,025.41 tonnes (COVID-19); whereas the market volume of the BMW recycling sector (India) was over around 70 thousand metric tons per annum in 2018 [36]. The figure 7 indicates the rise of BMW from 2010 (39.81%) to 2018 (69.64%) with slight drop in the 2012 (43.76%).

Hence, one can achieve the SDG 3.9 by controlling and implementing simple measures to minimize the pollution and thereby, protecting the humans health and protecting the environment with carbon zero.

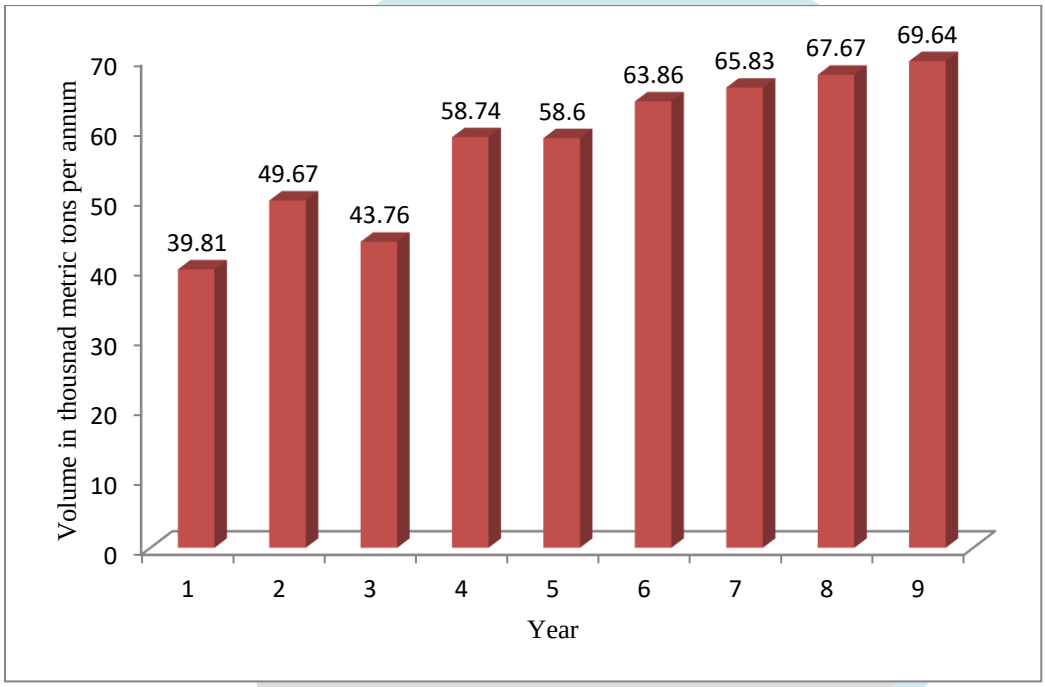

Figure 7. Market volume of BMW recycling across India from 2010 to 2018 Source: www.statista.com

IV. CONCLUSIONS

The medical device has to undergo several stages of perfection to be made available in the market. Recommending reusable devices, a hospital can reduce the cost of landfill, transport, CO2 emission ratio of waste treatment, and water-use. ANN proves the prediction of the pollution percentage in each region. ANN promotes automation wider and safer usage hence, SDG 3.9 can be achieved to a greater extent by reducing carbon emission to net zero.

REFERENCES

[1] https://earth911.com/inspire/infographic-our-plastic-earth/
[2] https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/
[3] https://www.onegreenplanet.org/environment/how-plastic-is-harming-animals-the-planet-and-us/
[4] https://www.craftechind.com/the-many-uses-of-plastic-materials-in-medicine/
[5] International Organization for Standardization (Switzerland). Environmental management: life cycle assessment: require-ments and guidelines, 2006.
[6] B. Vigon, et al. Life-Cycle Assessment: Inventory Guidelines and Principles. Cincinnati, OH: US Environmental Protection Agency, Battelle and Franklin Associates Ltd; 1992.
[7] J A Fava, et al. A Technical Framework for Life-Cycle Assessment. Washington, DC: SETAC and SETAC Foundation for Environmental Education, Inc; 1991.
[8] D S Jodi, et al. Life Cycle Assessment and Costing Methods for Device Procurement: Comparing Reusable and Single-Use Disposable Laryngoscopes. www.anesthesia-analgesia.org. 2018. Vol 127 (2). pg 434-443.
[9] WHO. Review of Health Impacts from Microbiological Hazards in Health-Care Wastes. Geneva: World Health Organization; 2004
[10] M Ioannis, et al., Environmental and Health Impacts of Air Pollution: A Review. Front Public Health. 2020; 8: 14. doi: 10.3389/fpubh.2020.00014

[11] https://www.unenvironment.org/news-and-stories/story/healthcare-waste-what-do-it
[12] https://earth911.com/business-policy/recycle-medical-equipment-reduce-waste/
[13] https://www.healthaffairs.org/doi/full/10.1377/hlthaff.2020.01118
[14] https://medical-technology.h5mag.com/medical_technology_nov18/breaking_point_should_we_be_reusing_more_medical_devices
[15] https://www.fda.gov/medical-devices/software-medical-device-samd/artificial-intelligence-and-machine-learning-software-medical-device#transforming
[16] J Philip & A. Ilke (2018). Single-use medical devices: Economic issues. Heart Asia 2018; 10:e011034. doi:10.1136/heartasia-2018-011034
[17] J B Pietzsch et al. Stage-Gate Process for the Development of Medical Devices.J. Med. Devices 2009,3, 021004
[18] M Petra et al. Complexity Stage Model of the Medical Device Development Based on Economic Evaluation—MedDee. Sustainability 2020, 12, 1755; doi:10.3390/su12051755
[19] S C Geoffrey, Shelf Life Of Medical Devices April 1991, https://www.fda.gov/media/72487/
[20] J E Matthew et al. Estimated Global Disease Burden From US Health Care Sector Greenhouse Gas Emissions. AJPH Supplement 2, 2018, Vol 108, No. S2
[21] H B Lawrence et al. The Energy Burden and Environmental Impact of Health Services. American Journal of Public Health. 2012, Vol 102, No. 12.
[22] C Bulim et al. Carbon Footprint of Packaging Films Made from LDPE, PLA, and PLA/PBAT Blends in South Korea. Sustainability 2018, 10, 2369; doi:10.3390/su10072369.
[23] US-FDA-Artificial-Intelligence-and-Machine-Learning-Discussion-Paper.pdf
[24] B L Karthik , et al. Characteristics of the Ozone pollution and its health effects in India. Int J Med. Public Health. 2017; 7(1): 56-60.
[25] S Geravandi et al. Sulfur and Nitrogen Dioxide Exposure and the Incidence of Health Endpoints in Ahvaz, Iran, Health Scope. 2015 ; 4(2):e24318. doi: 10.17795/jhealthscope-24318.
[26] J Prisilla & M Iyyanki. Deep Learning Techniques for Prediction, Detection, and Segmentation of Brain Tumors. *IGI Global*. *Deep Neural Networks for Multimodal Imaging and Biomedical Applications.* 2020. 118- 154. DOI: 10.4018/978-1-7998-3591-2
[27] R Vinuesa et al. The role of artificial intelligence in achieving the Sustainable Development Goals. *Nature Communications* volume 11(233) 2020.
[28] imdrf-tech-140918-samd-framework-risk-categorization-141013.pdf
[29] https://www.mddionline.com/software/how-artificial-intelligence-changing-medical-devices
[30] https://emerj.com/ai-sector-overviews/ai-medical-devices-three-emerging-industry-applications/
[31] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/deciding-when-submit-510k-software-change-existing-device
[32] https://www.medicaldesignbriefs.com/component/content/article/mdb/features/articles/26074
[33] https://www.atrify.com/en/news/data-integrity-is-key-for-the-medical-device-industry/
[34] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/medical-product-communications-are-consistent-fda-required-labeling-questions-and-answers
[35] WHO. Medical devices: Managing the Mismatch An outcome of the Priority Medical Devices project. ISBN 978 92 4 156404 5
[36] https://www.statista.com/statistics/1050938/india-biomedical-waste-recycling-market-volume/