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Carbon Footprint Analysis & Prediction: A Case Study of Mehran University of Engineering & Technology, Pakistan

Uroosha Memon[1], Areej Fatemah Maghji[1], Mohsin Ali Memon[1]

[1]*Department of Software Engineering, Mehran University of Engineering and Technology Jamshoro Sindh, 76090, Pakistan*

Abstract: The last few decades have witnessed a progressive increase in carbon footprint emissions. There are different factors raise carbon footprint. Two such factors are plastic and paper, the use of which is increasing in our daily lives. Different strategies are followed by organization on a global scale to maintain their carbon footprint, but the strategies aimed at plastic and paper for greenhouse gas mitigation have not been fully explored. This study focuses on the carbon footprint generation for plastic and paper used by five departments of Mehran University of Engineering and Technology, Jamshoro. This study uses the data from 2017-2021 to predict the carbon footprint for the next five years based on plastic and paper consumption.

Keywords: *Carbon Footprint, Carbon Footprint Forecasting, ARIMA, Global Warming, Greenhouse Gas Emissions.*

1. Introduction

Recently, Carbon Footprint (CF) has been a buzzword for the world. CF generation is a majorly discussed topic around the globe. The world is facing an unprecedented situation in the form of climate change, rising sea levels, melting of polar ice, and many other similar issues. Today the world is using plastic and paper on a large scale. Our planet is unimaginable without plastic and paper. The extraordinary level of plastic production and use has been noticed around the world. According to the last calculated world record for CO_2 emission, the world emits around 43 billion CO_2 emissions [1]. At the same level of emissions, there will be 12,000 Mt of plastic in our natural environment [1].

Globally, countries, originations, governments, and individuals are affected by climate change. It is a phenomenon that affects both natural and human habitats [2]. The world concerns are about growing about climate change as the Greenhouse Gas (GHG) emission levels are rising. It is giving an alert to the human being to tackle the situation in this high time, as the risk for climate change is growing. The researcher are working on the paper industry and its contribution to GHG emissions [3]. Industries around the globe are responsible for the GHG emissions for 21% of overall emissions [4]. The paper industries are producing around 400 million metric ton calculated for 2018 and is continuously growing [5]. Paper takes as much energy as it takes to make a ton of steel. The paper decomposition is the more damaging GHG because paper is either turn into methane or CO_2.

Currently there is study-lack found to provide strategies that reduce the impact of paper and plastic on the environment. We cannot complete remove plastic or paper from our environment but we can control the use of these two parameters. This study proposed a methodology for MUET, while considering two parameters paper and plastic. This study works on the prediction python model by using ARIMA algorithm.

The paper is organized as follows: section 2 presents a literature review, section 3 outlines the methodology of this paper, and section 4 presents an implementation followed by the results presented in section 5. Section 6 comprises of the conclusion of this paper.

2. Related Work

The Birla Institute of Technology & Science (BITS) Pilani, India worked on CF emission for their campus. They worked on the direct and indirect emission using the Life Cycle Assessment (LCA), Ecoinvent version 3.0 database, ISO 1064, and Umberto NXT Universal software to calculate the CO_2 emissions. This study takes into account Intergovernmental Panel on Climate Change (IPCC) for assessment of CO_2 emissions. The three scope definition were used to distribute the parameters and result visualization. Data of 2014-2015 was used to calculate CO_2 emissions. The results of this research show that electricity from Scope 2 is the major contributor with 50%, scope 3 contributes as a 2nd major contributor with 48.9%, and scope 1 with 1.1% is the lowest contributor to GHG emission for BITS [6].

University of Talca (UT) has been monitoring GHG emissions. They considered all their campuses for their research. Direct and indirect emissions were considered to meet three scope definition. The reported emission for GHG were associated with scopes 1-3. This study calculated the GHG emissions for the resources used in campuses, give results, and suggestion for the reduction of CO_2 emissions. The results were represented as CO_2 emission per person per year that is 20.03t CO_2 e, and 0.25t CO_2 respectively. Scope 3 for UT produces 0.41t CO_2 e for each person per year for 2016 [7].

Corresponding author Email address*: urooshamemon22@gmail.com*

This research examines that without synthetic organic compounds and plastics seems incredible nowadays. The study analyzes data between 1950 to 2015, the beginning of the plastic production model by resins which is published by the Plastic European Market Research Group between 1970 to 2015 in the annual fiber production data published by Fiber Year and Tecnon OrbiChem.

The usage and production of synthetic polymer, resins, fibers, plastic present globally manufactured. In this paper they evaluate that virgin plastic produced about 8300 million metric tons (MT) and in 2015 wastage of plastic was about 6300 MT from 9% recycled 12% burn up, 79% amassed in landfills. The resins data follow the 2nd order polymer time trend to produce R2 = 0.9968 and the fiber data follow the 3rd order polymer time trend which produced R2 = 0.9934 and currently there is no consequential to recycling of Synthetic fibers so it's supposed that textiles' end-of-life is carbonize with the other solid materials [8].

This Research examines that Hybrid LCA approach and come up with the designed methodology to estimate the CF of copying paper in meditation short term of carbon storage. This method applied on China's paper mill and measure the effects of delaying GHG emission. This paper works on two scenarios, 1st they consider the burning of wastage copying paper, and 2nd consider the reuse of the paper. The output shows that carbon footprint of 1000kg copying paper in 1st scenarios and 647.89kg -5094kg in 2nd scenarios. Consumer take in to consideration while using the copying paper to reuse and recycle the item to increase the carbon storage as much as possible. [9].

3. Methodology

This study focusing on analysis and prediction for next five years for five departments of the main campus of Mehran University of Engineering and Technology, Pakistan (MUET). The departments of the Faculty of Electrical, Electronics and Computer Engineering (FEECE) have been considered.

The research methodology is given in Fig.1. The outline of this methodology comprises of Data collection, Data Transformation, CF calculation, Python Script and ARIMA algorithm for prediction and analysis, and then finally visualization of results and comparison. This research developed a python model using ARIMA algorithm. The real data was collected for Paper and Plastic from the department of MUET main campus for 5 years (2017-2021). After the data collection, data was transformed into required format into Comma Separated values (CSV).

$$CF_{(plastic,\ Paper)} = AR_{(Plastic,\ Paper)} * EF_{(Paper,\ Plastic)} \quad (1)$$

The formatted data was converted into CF by using emission factor for plastic and paper individually. CF calculation is made by using equation (1). The python model was used to forecast CF for next five years for five departments. The predicted values are compared to measure the major contributor to the GHG emissions. The obtained results are plotted on the graph for the better visualization and comparison.

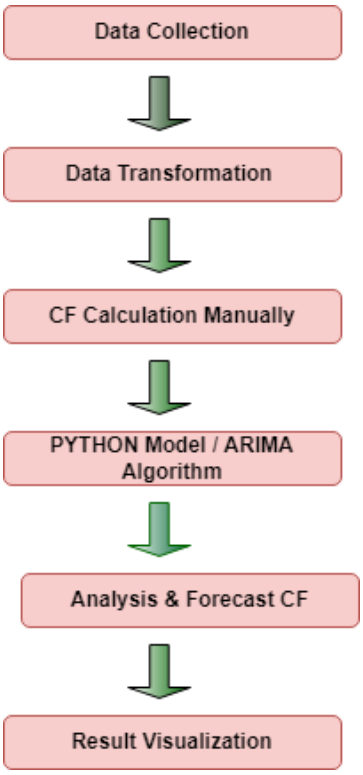

Figure.1. Proposed Methodology

3.1 Data collection

The Data collection is the basic, important, and time taking process of this methodology. It takes months to work on the real time data of five departments for two different parameter to get the required and formatted data. The formatted data was converted into CF manually by using equation (1). Equation comprises of two component. AR is activity rate for the parameter in which parameters is used. EF is the emission factor for each parameter such as for plastic and paper. Table.1 outlines the data collection process and transformation.

Table.1. Statistical data

Data Collection	Data Availability
Plastic Data	Collection of data for Plastic of last five years from five department of MUET.
Paper Data	Collection of data for Plastic of last five years from five department of MUET.
CF Calculation	Collected data was then transformed into CF manually by using eq.1.
Prediction using python model	Collected data was then transformed into CF manually by using eq.1.

The data collection is made manually from FEECE faculty of MUET main campus. Data was collected from five departments: Software Engineering (SW), Telecommunications Engineering (TL), Bio-Medical Engineering (BM), Computer Systems Engineering (CS), and the Institute of Information and Communication

Technologies (IICT). Plastic and Paper data was maintained in .csv file for python model.

3.2 ARIMA Prediction Model

This study proposed a methodology that used the python platform for prediction and analysis for five years. Perdition model is a python script that worked on ARIMA for forecasting the CF for five years. ARIMA is used to predict the given time series data. It examines each variable by auto regressive and moving average to predict the fluctuations by targeting the past data [10, 11]. In addition, time series data uses on-way natural time ordering, and uses past values to derive for given period of time [12, 13]. ARIMA used statically data for prediction [14, 16]. ARIMA Forecasting is based on weighted value and exponential soothing depending on past data. ARIMA Prediction Model is used to forecast CF for MUET main campus.

4. Implementation

The proposed methodology of this paper is outlined in Fig.1. We have developed a python model for the CF prediction for MUET. The Python model analyze and predict for past data. Python script uses the structured csv file data to forecast for each parameter. The formatted file contain data for two parameter for five department for 5 years. Prediction is calculated on each parameter individually and as whole. Provided past year data was time series data. Time series data gives better understanding and visualization for the future results 2017-2021 data is used for the prediction for next five years. For each parameter last five year data has been processed on python script. Weighted value is used to give input to the model [15, 17]. A weighted value is calculate to give input in the model for prediction. Previous data is used to calculate weight value. The predicted values for each is then plotted on the graphs for better visualization.

4.1 Python Model

We developed a Python model for forecasting. Python Model is developed by using different libraries such Read csv, pyplot, Datetime, Mean square error. Libraries are required for analysis and prediction. ARIMA algorithm used for forecasting for plastic and paper. Final results were then gathered for each parameter individually and as whole. The results were then compared to identify the major stressor to the GHG in the boundary of MUET for five departments. The final results are deployed on the graphs.

5. Results and Discussion

This study analyzed and predicted the CF for next five for five departments of MUET, main campus. The python model is used for forecasting. The observed results suggested that among plastic and paper, paper is the major contributor to the GHG emission for the five departments of MUET. Paper is the most used parameter among the departments.

Table 2 comprises of the predicted values for five departments. Among all mentioned departments, Institute of Information and Communication Technology (IICT), is the major contributor to the GHG, and Software Department (SW) is the least contributor to the GHG emission for Paper, when it comes to Plastic the major contributor is Telecommunication Department (TL), however SW is the least contributor to GHG emissions.

Table.2. Data Collection and Availability of Data.

Department	Forecasted CF for Plastic	Forecasted CF for Paper
SW	1.2E+01	1.47E+02
IICT	2.2E+01	2.23E+02
CS	2.2E+01	1.84E+02
BM	2.2E+01	1.77E+02
TL	2.6E+01	1.88E+02
Total	1.06 E+02	9.21E+02

5.1 Paper Prediction CF

Fig.2 and Fig.3 is the visualization for Table 2. Fig.2 discussed the usage of paper for next five for departments of MUET. This visualization suggested that the department with the highest CF Predicted value should work on managing the use of less paper. The results also shows that the paper is the most used parameter in the university premises among plastic and paper. IICT is considered as highest CF generation with 24%, followed by TL with 21%, Computer System (CS) with 20%, Biomedical Department (BM) with 19%, SW with 16%.

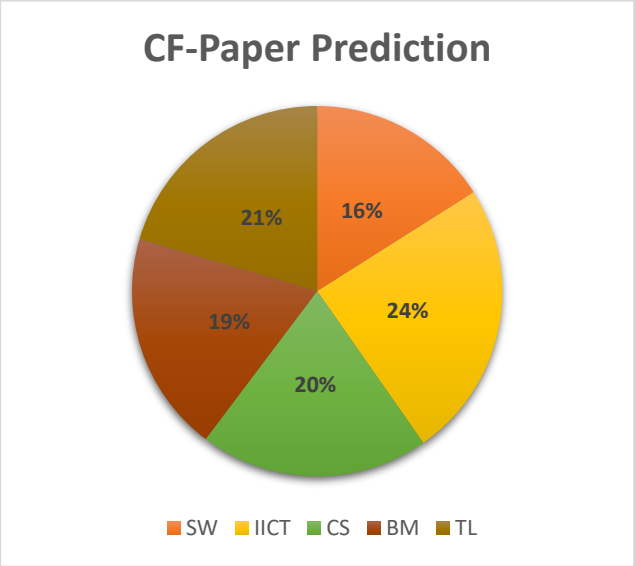

Figure.2. Illustration of CF Prediction for Paper.

5.2 Plastic Prediction CF

The prediction results for next five years for five departments of MUET are presented in Fig.3. Observing the results, with 24% CF generation TL is the major contributor for Plastic CF, followed by BM with 22%, CS and IICT ranked same with 21%, and SW with 12%.

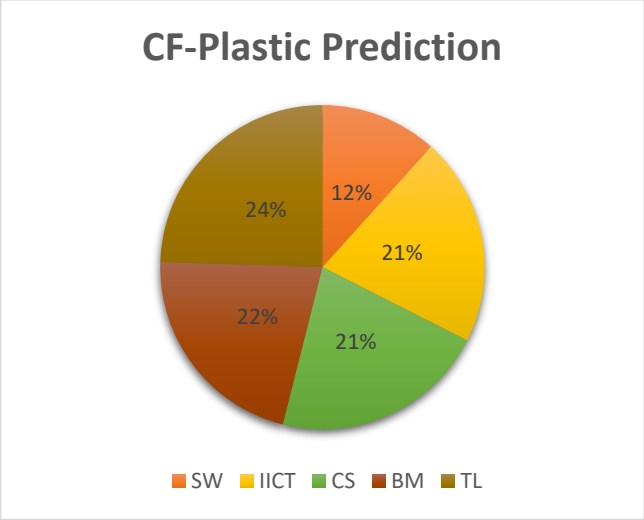

Fig. 3. Illustration of CF Prediction for Plastic.

5.3 CF Results Comparison for Plastic & Paper

Fig. 4 and Fig.5 is the comparison of CF for Plastic and Paper. The results showed that Plastic CF generation is less than Paper CF generation. Fig.4 shows that Paper usage and its CF is maximum as compare to the plastic. The highest rank for CF of Plastic goes up to 4.00E+01 approximately. However, CF for paper goes up to 2.50E+02 approximately. IICT is ranked as the highest CF generated department for plastic and paper both with around 2.50E+02. TL ranked with 2nd major contributor with 2.10E+02 approximately. CS with 2.00E+02, and BM with 1.90E+02 CF for Plastic and paper.

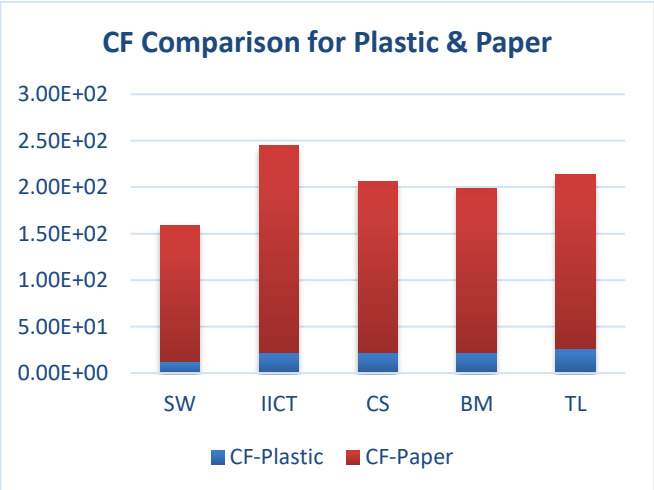

Fig. 4. CF Comparison for Plastic & Paper.

Fig.5 discussed that paper graph line goes down during 2019 to 2020 as the activities of the university was stop during pandemic due to COVID 19 and it is again going up as the 2022 is starting this show that during pandemic the usage of paper goes down for time and it also effect the CF generation. However, the plastic usage remains constant almost every year in past and expected to be same in the future with a little rise in graph line.

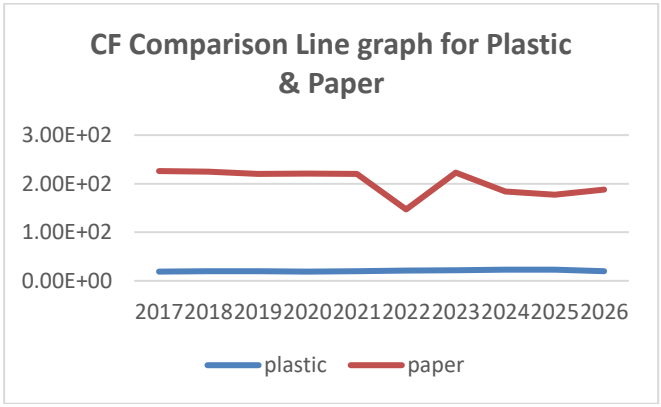

Fig. 5. CF Comparison Line graph for Plastic & Paper.

5. Conclusion

This study demonstrates that ARIMA algorithm can be used for technical analysis for forecasting dependent on the past value [16, 18, 19]. The developed python model evaluates the CF and predict the CF for next five year of departments of MUET for FEECS faculty. Python Model was applied to the paper and plastic data. Data collected for year 2017 to 2021. The developed methodology uses ARIMA algorithm for forecasting. The results shows that 1.06 E+02 kg CO_2 for Plastic and 9.21E+02 kg CO_2 for paper. This paper suggested that we as students, faculty, and organization should raise our concern about our environment and pay our attention to make less use of plastic, paper and recycle our products to support sustainability and green planet.

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About Authors

Uroosha Memon

Department of Software Engineering, MUET, Jamshoro
Email: urooshamemon22@gmail.com

Areej Fatemah Meghji

Department of Software Engineering, MUET, Jamshoro
Email: areej.fatemah@faculty.muet.edu.pk

Mohsin Ali Memon

Department of Software Engineering, MUET, Jamshoro
Email: mohsin.memon@faculty.muet.edu.pk