Journal of Materials and Environmental Science
ISSN : 2028-2508
e-ISSN : 2737-890X
CODEN : JMESCN

J. Mater. Environ. Sci., 2024, Volume 15, Issue 12, Page 1684-1693

http://www.jmaterenvironsci.com

Carbon footprint evaluation of small-scale industries in Benin city, Nigeria

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Received *09 Sept 2024,*
Revised *29 Nov 2024,*
Accepted *08 Dec 2024*

Keywords:
✓ *climate change,*
✓ *carbon,*
✓ *emission,*
✓ *industries,*
✓ *awareness*

Citation*: Odiana S., Okhiriiia F. L. (2024) Carbon footprint evaluation of small-scale industries in Benin city, Nigeria, J. Mater. Environ. Sci., 15(12), 1684-1693*

Abstract: Climate change is the greatest environmental problem in the world today and as such, there is great need to calculate the carbon footprint so as to help reduce the emissions of Greenhouse Gases. This study aims to assess the carbon footprint of small-scale industries in benin city. ISO 14064 carbon footprint calculation model was used to compute the carbon footprints of the small-scale industries. Also, 120 Questionnaires designed in likert-scale was used to collect information from respondents. The findings showed that most of the industries exceeded the ideal carbon footprint range of 2.62 - 7.64. The awareness level of the respondents on greenhouse gases was found to be low. The result also revealed that not much is done to reduce greenhouse gas emissions in the small-scale industry. It was deduced that the carbon footprint of the small-scale industry in the study area is high. Therefore, efforts should be made by these industries to reduce their carbon emission. Also, relevant agencies should intensify awareness on climate change and related matters.

1. Introduction

Climate change is a change in the state of the climate that can be identified (using statistical test) by changes in the mean and /or the variability of its properties, and that persists for an extended period, typically decades or longer. (IPCC, 2012). It is the greatest environmental problem in the world today (Onoja *et al.*, 2011) with numerous effects cutting across most sectors of humans. It is caused majorly by carbon emissions from different sources among which include industrial sources as such, there is great need to evaluate the carbon footprints of emission sources so as to help reduce the emissions of this greenhouse gas consequently mitigating climate change. Studies have shown that carbon emissions have increased tremendously causing the rise in the average global temperature by

0.8 ◦C over the last century, and are anticipated to ascend more in the next century and since the 1970's, it has rised by 0.5ºC (Scafetta, 2010). Carbon footprints assessment is one way of determining the contribution an emission source has to climate change.

Carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product (Wiedmann and Minx, 2007). The carbon footprints of both industry and individual can be assessed so as to determine the amount of carbon added to the atmosphere which could result to climate change. The carbon footprint of a company represents an indirect indicator of the consumption of energy, products, and services (PwC, 2020). About a quarter of greenhouse gas emissions are from industrial sources commonly due to on-site burning of fossil fuels for heat and electricity, waste materials generated, non-energy usage of fossil fuels, and chemical processes used in the manufacturing of iron, steel, and cement. (C2ES, 2023). A small scale enterprise is a business that is not large, in terms of size, scope of operation, finance and the personnel involved. For example, Napkins, tissues, chocolates, toothpick, water bottles, small toys, papers, pens industries (Obi, 2015). Small Scale Industries could be found in designated areas or areas close other land uses like as commercial and residential, as well as mixed residential/commercial (Mbuligwe, 2011). Several studies have been done to evaluate carbon foot print of industries among which include Al-Amin et al. (2009) in Malasyia; Mashok***o*** ***et al.*** (2010) in South Africa; Awanthia and Navaratn (2018) in Sri Lanka

Small scale industries characterized urban environment like Benin City Nigeria. They are source of employment to people and revenue to the government at all levels. With this in mind, there is the proliferation of small scale industries in many cities including Benin. These industries in Benin City rely mostly on fossil fuels for their operations and logistics. As such contribute to emissions of greenhouse gases like carbon which massively contribute to climate change. With the quest for economic development, there is the proliferation of divers kinds of small-scale industries in Benin City which consequently contribute carbon into the atmosphere. It is therefore necessary to assess the carbon footprint of small-scale industries. This study aimed at evaluating the carbon footprint in selected small-scale industries in Benin City, Nigeria.

2. Materials and methods

The study area as shown in figure 1below is Benin City in Nigeria located in the southern part of Nigeria and serves as the capital of Edo State with latitude 6° 44'N and 6°21'N and longitude 5°35'E and 5°44'E. It has a population of 3,233,366 according to the 2006 National Population census with a projected population of 1.3 million by 2010 at 2.9% growth rate (NPC, 2024). Benin City is a humid tropical urban settlement, which comprises occupies an area of about 1125 km² and situated on fairly flat land, about 8.5km above sea level. (Iyalomhe and Cirella, 2018). Benin City is located in the humid tropical rainforest belt of Nigeria. The rainy season begins in March/April and ends in October/November with average annual rainfall of 2284.5mm and a dry season lasting from November to February (Odiana and Idahosa-Ohio, 2023).

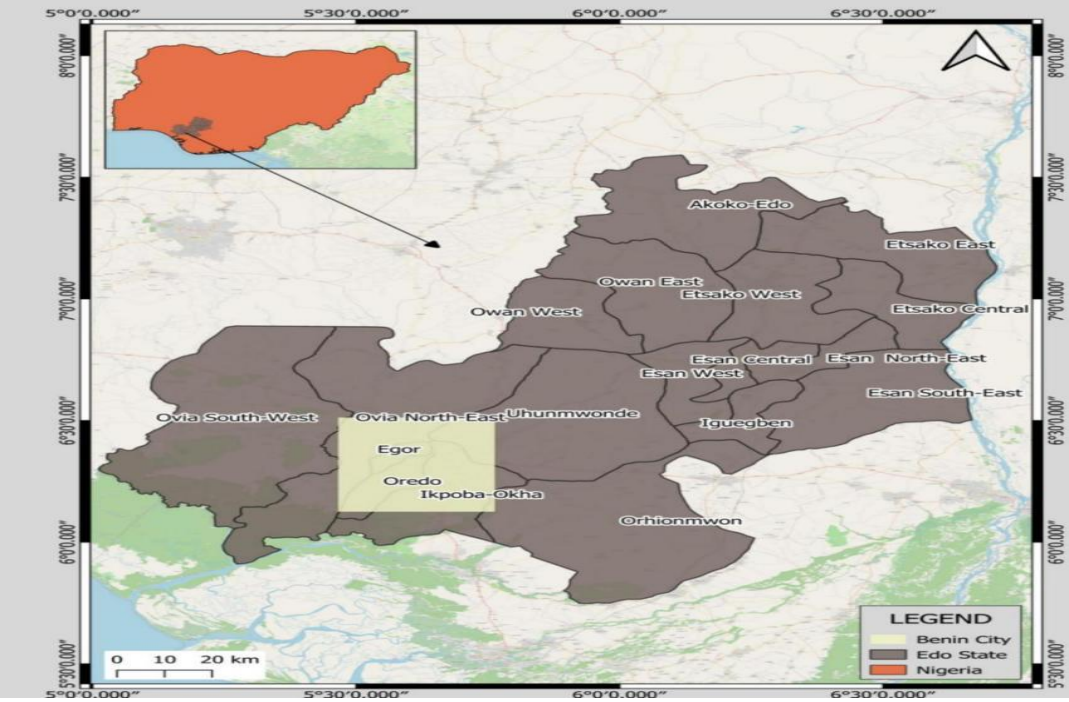

Fig 1. Map of the study area

Source of Data

For the purpose of this work, a primary source of data was utilized. Data on the energy usage that emit carbon were obtained from Bakeries, Water companies and Printing press around the study area. A likert-scale questionnaire was also used to determine level of awareness and measures taken to reduce greenhouse gases in the respective industries.

Sampling Techniques

This study centered on randomly selected small-scale industry in Benin City, which include three bakeries, three water factories, three sawmills and three printing press. Ten questionnaires were distributed to each of the small-scale industry, making a total of One hundred and twenty (120) questionnaires.

Method of Data Collection

The researcher went to the randomly selected small-scale industries in Benin City among which includes; bakery, water factories, printing press and sawmills to distribute questionnaires. The researcher gave the questionnaires to both the management staff and other persons working in the factories. The respondent filled the questionnaires on the spot and they were retrieved from them immediately. This was done to enable researcher to obtain information regarding the carbon footprint of the small-scale industries in Benin City. The questions focused on the direct emission, indirect emission of carbon, evaluation of the level of awareness and the measures taken to reduce greenhouse gas emissions in the small-scale industry.

Method of Data Analysis

The data obtained was analyzed using descriptive statistics such as mean and standard deviation. The carbon footprint of the small-scale industries was determined using the carbon footprint formula developed by International Organization for Standardization (ISO 14064).

Items on the questionnaires responded by the owners and workers of the small scale industry with a mean value of 2.5 and above were regarded to be in the affirmative.

3. Result and discussion

Demographic Characteristics of the respondents

The gender, age, work experience and educational level of the owners and workers in the small scale industries visited are shown in Table 1 below. There were 70.0% male and 30.0% female which means that most of the respondents were male. In terms of age, 32.5% were between 20-30 years, 35.0% were between 31-40 years, 19.2% were between 41-50 years and 13.3% were above 50 years. This showed that most of the respondents were in their economically productive age. This implies that they have high tendency of continual working or getting involved in industry for some time thereby continuously involved in carbon emission and consequently increasing their carbon footprint.

Table 1 Demographic characteristics of the respondents

Characteristics	Components	Frequency	Percentage (%)
Gender	Male	84	70.0
	Female	36	30.0
	Total	120	100.0
Age	20-30	39	32.5
	31-40	42	35.0
	41-50	23	19.2
	50 AND ABOVE	16	13.3
	Total	120	100.0
Work experience	0-5	60	50.0
	6-10	29	24.2
	11-15	20	16.7
	16 Years and above	11	9.2
	Total	120	100.0
Educational Level	Primary	39	32.5
	Secondary	42	35.0
	Tertiary	23	19.2
	No formal education	16	13.3
	Total	120	100.0

Source: Researcher's computation, 2024

As shown in the table, most of the people had working experience of 15 years and below. Only 11% had 16 and above years of working experience. It could imply that there might be the challenge of the

workers not handling the equipment in an efficient way that will reduce carbon footprint of the industries. The result also revealed that 32.5% had only primary school education, 35.0% had secondary education, 19.2% had tertiary education and 13.3% had no formal education signifying that most of them are literate. Being mostly literate connotes that accepting innovations and best practices that could help in reducing carbon footprint would not be a much challenge by the owners and workers of the industries.

Determining Direct Carbon Footprint

The carbon footprint of the various small-scale industries visited as a result of their direct emission is as shown in table 2 below. The carbon footprint ranges between 2.30tCO_2 and 108.58 tCO_2. According to ISO 14064, Ideal carbon footprint is between 2.72 and 7.26tCO_2; Average carbon footprint is between 7.26 and 9.98 tCO_2; Over 9.98 tCO_2 is considered to be in the excess while below 2.72 is said to be too low.

Table 2 Direct Carbon Footprint of the small scale industries

Small Scale Industry	Carbon Footprint (tCO_2)
B1	2.30
B2	30.41
B3	26.90
W1	108.58
W2	108.31
W3	23.88
P1	18.93
P2	18.10
P3	11.59
S1	16.71
S2	11.92
S3	9.08

Source: Researcher's computation, 2024

Determining Indirect Carbon Footprint

The carbon footprint for the different small-scale industries visited as a result of their indirect emissions is shown in the table 3 below. The range for their carbon footprint is between 0.03tCO_2 – 8.4tCO_2. According to ISO 14064, Ideal carbon footprint is between 2.72 and 7.26tCO_2; Average carbon footprint is between 7.26 and 9.98 tCO_2; Over 9.98 tCO_2 is considered to be in the excess while below 2.72 is said to be too low.

Determining Level of Awareness of Greenhouse Gases By the Owners and Workers of the Industries

The mean of the result on awareness of greenhouse gases as shown in figure 2 below revealed that the respondents had weak agreement with some of the items analyzed. Therefore, from the result, it can

be inferred that the level of awareness of greenhouse gases by the owners and workers of the small scale industries is low.

Table 3 Indirect Carbon Footprint of the small scale industries

Small Scale Industry	Carbon Footprint (tCO_2)
B1	7.16
B2	7.67
B3	6.84
W1	0.03
W2	8.46
W3	5.51
P1	6.47
P2	7.71
P3	6.06
S1	3.49
S2	3.12
S3	5.69

Source: Researcher's computation, 2024

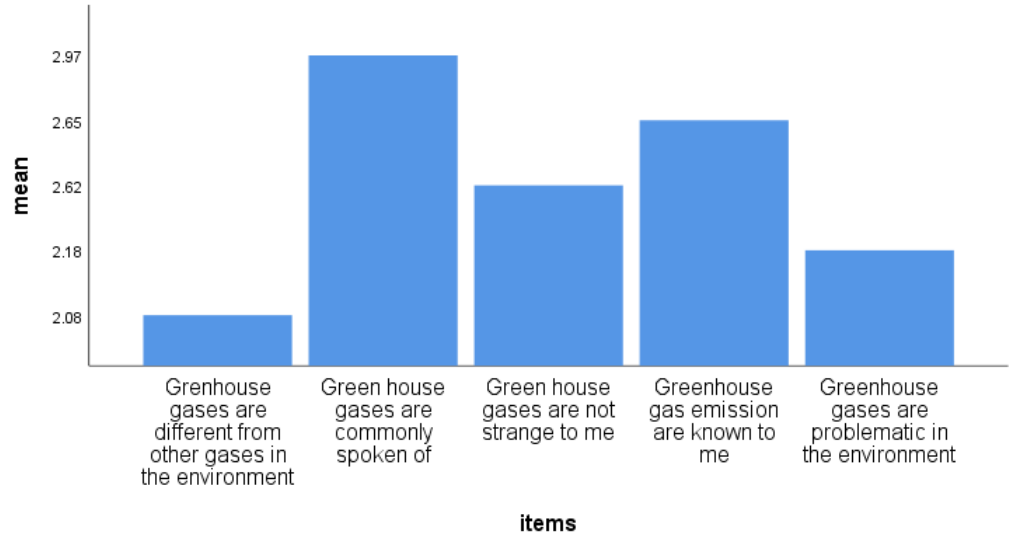

Fig. 2 Level of awareness of greenhouse gases in the study area

Determining the Measures Taken to Reduce Greenhouse Gas Emission in the Industries

The mean of the measures taken to reduce greenhouse gas emissions as shown in fig 3 below revealed that the respondents also had weak agreements with some of the items analyzed. It can therefore be deduced that not much measures are taken to reduce greenhouse gas emission and consequently carbon footprint in the small-scale industries.

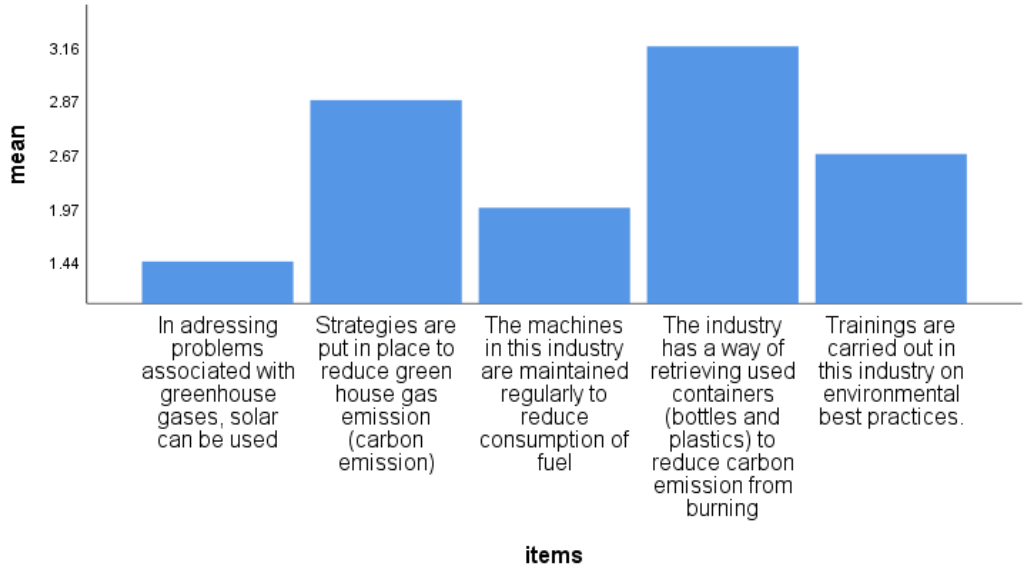

Fig 3. Measures taken to reduce greenhouse gas emissions in the study area

The result in this study showed that the direct carbon footprints of all the industries except one exceeded the ideal carbon footprint of 2.72 – 7.26tCO_2 stated by ISO 14064. Awanthia . and. Navaratnea (2018) in their study got values of up to 36.09 tCO2e/year in the organization they studied. Similar studies done by Awanthia . and. Navaratnea (2010) and Awanthia . and. Navaratnea (2017) reported carbon footprints of 418.5 tCO2e/year and 73.25 tCO2e/year respectively. In this study, it can be implied that the direct carbon footprints of the industries studied are high, thereby, there is need to put in/or intensify effort towards reducing carbon emissions in the industries so as to reduce their carbon footprint. This is in agreement with the study done by Casey and Holden (2005c) where they asserted on efforts like improved farming intensity to decrease total GHG emissions. This study revealed that high amount of carbon emission resulting to climate change could come from small-scale industries. Therefore, to mitigate climate change in the study area, there is need for small scale industries to put in more effort and measures to reduce carbon emission. As such they should not be excluded in climate change mitigation plans. Studies have shown evidences of climate change in the study area among which include Floyd *et al.*, (2016); Odiana and Idahosa-Ohio (2023); Balogun *et al.*, (2023); Odiana and Ochulor (2024). Climate change has a lot of effect on man and the environment among which include flooding, drought, health, etc. In the study area, flooding is a major problem which can be attributed to climate change (Odiana and Idahosa-Ohio, 2023). This pose serious problem to farmers as their crops and farmland are usually affected. More so, they have poor flood coping capacity and preparedness measures (Odiana *et al*., 2023; Odiana *et al*., 2022).

The results from the study area revealed that water factories contribute the highest carbon footprint followed by bakeries with sawmills and printing press having the lowest carbon footprints. This could denote that the production process of consumables which are constantly in need by the end users, have significant impact on the carbon footprint. Nearly one-third of the world's energy consumption and 36% of its carbon dioxide (CO2) emissions are attributable to manufacturing

industries (Gielen *et al.*, 2008). In this study, diesel oil was shown to be the primary energy consumption in these subsectors, accounting for a large percentage of final energy consumption and gasoline being the next largest energy source. As such there is high dependence on fossil fuel related energy source among industries in the study area. The continuous need for these consumables puts a strain in the manufacturing processes, ultimately leading to increase emission of greenhouse gases. Inah *et al.*, (2022) reported in their study that production structure has a direct relationship with energy intensity which results in a CO_2 emission increase.

The outcome from this study shows that 75% of the industries had their indirect carbon footprint within the ideal emission which ranges between 2.72 and 7.26tCO_2 in accordance with ISO 14064. This could be attributed to the fact that most of the supply of the products are done by the industry-owned vehicles. It could also be deduced that most workers commute by public transportation. In the study done by Herth and Blok (2022), they reported that indirect emissions are often only partially accounted for. With the carbon footprint of most of the industry within the ideal emission values, it could therefore be said that the contribution of the industries' indirect emission to global warming and consequently climate change is low.

The level of awareness in the study area

This study revealed that the level of awareness of greenhouse gases and ultimately climate change is perceived to be low which is consistent with the study done by Odiana *et al.*, (2024). A possible explanation for these could be that there is dearth of climate change related information/awareness among the owners and workers in the small-scale industries. In contrast to this study however, Gobir *et al.*, (2021) in Lagos and Benue States revealed higher climate change awareness of 84.0% and 92%, respectively. Awareness of greenhouse gases by individuals is necessary if the menace of climate change will be mitigated because climate change mitigation among other things involves attitudinal change by humans. With the low awareness of greenhouse gases, it will pose some challenge in mitigating climate change among the owners and workers of small-scale industries and the general populace in the study area. However, their literacy level is high as such, they could be easily enlightened on climate change matters so as to achieve emission reduction and climate change mitigation.

Measures taken to reduce greenhouse gases in the study area

The outcome of this study shows that measures taken to reduce greenhouse gas emission are low which tallies with the findings of Odiana *et al.* (2024). This could be attributed to the dependence on fossil fuels for energy as well as low levels of awareness of the greenhouse gases by the respondents. Many industries, due of limited electricity supply from the national grid, provide their own electricity for business and personal use by means of privately owned fossil fuel powered generators (Oyedepo, 2012). This may also be due to the inability of the industries transition to cleaner sources of energy (such as natural gas, hydro, solar, etc.) as a result of cost and other factors. The low measures taken to reduce greenhouse gas emission in this study further expose the fact that not much is done by relevant authorities to reduce greenhouse gas emission in the study area and in the nation at large.

Conclusion

This study assessed the carbon footprint in small-scale industries across Benin City using questionnaire designed in likert-scale to get information from respondents in bakeries, water factories, sawmills and printing press. The results revealed that the carbon footprint of most of these industries in Benin exceeded ideal carbon footprint of 2.72 and 7.26tCO_2 in accordance to ISO 14064. This could be attributed to the dependence on fossil fuels for energy to a large extent. The negative impact of a high carbon footprint is increase in global warming and consequently climate change.

Disclosure statement: Conflict of Interest: The authors declare that there are no conflicts of interest.

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