Evaluation of the Effectiveness of Adaptation Measures of Manufacturing Industries to the Effects of Climate Change

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ABSTRACT

This study researched on the process of adaptation of manufacturing industries to the effects of climate change with Nairobi Bottlers a Coca Cola company as a case study. Specifically, the study analyzed the trends of atmospheric pollutants that is surface ozone and how the adaptations are contributing to efficient use of energy and water resources. The atmospheric pollutants were determined from the surface ozone which was based on total LPG and diesel fuels consumed. The results showed that the there is a linear increase in the surface ozone attributed to atmospheric pollutants in the period of study. There was a linear correlation between the surface ozone calculated from the consumed fuel and surface ozone measured indicating an increase in concentration of surface ozone in the atmosphere during the period of study. A study on the adaptation measures showed an improvement in process efficiency of the company. The results of this study showed that adaptation measures can reduce on effects of climate change and improve on process efficiency of manufacturing companies.

Keywords

Climate change, adaptation measures, manufacturing industries, Surface ozone equivalent

1. INTRODUCTION

The term climate change is often used interchangeably with that of global warming but it is growing in preference use because it helps convey that there are other climatic changes in addition to rising temperature. Usually, climate change can be viewed as the combination of various natural forces occurring over diverse timescales - the classical period is three decades, as defined by the World Meteorological Organization (WMO). In mitigating effects of climate change, adaptation mechanisms are employed. The process involves the altering of business processes and infrastructure to respond to climate change. It often includes building up capacity to adopt as well as minimize, adjusting to and taking advantages of the consequences of climate change [1].

In the recent years, the effect of climate change has prompted manufacturing companies to adapt to certain measures. Companies have improved their manufacturing technologies to increase processing yields and efficiencies in light of anticipated declines in yields, decreased water availability, and increased energy costs. For instance, companies are adopting products developed to enable adaptation to water scarcity (e.g., enzymes for cold- and reduced-water textile washing) and rising energy costs (e.g., ingredients to reduce refrigeration needs for ice cream); Unilever India, harvests rainwater at a quarter of its factories; Siemens has developed a dedicated "environmental portfolio" of carbon-efficient products etc. [2]. All these efforts are to reduce on effects of climate change which impact the earnings of the manufacturing companies [2].

A recent McKinsey Global Survey found that companies with a unified strategy to adaptation of climate change are likely to be among the strongest performers, both financially and on measures of sustainability [2,3,4]. Coca-Cola, for example, has set for itself a strategy which encompasses its approach to improving personal health and wellness, the communities in which it operates, and the environment. Similarly, the beer company MillerCoors tracks and quantifies progress in areas, ranging from water to energy to packaging to human rights, using its own sustainability-assessment matrix [2,5].

The manufacturing sector draws raw material from nature which destabilizes the environment from production of solid wastes, liquid and gas. This makes manufacturing sector part of the climate change both by contributing to it and also being impacted by changes. Climate change is beginning to influence action in the manufacturing sector, but for the most part, accounting for climate change is not common in business activities and decisions [6, 7]. Manufacturers need to be aware of the effects of climate change, and begin to prepare assets and operations for the anticipated impacts [8]. Adaptation strategies can increase resilience and help to protect investor property and supply chains. The study was done at Nairobi Bottlers Limited, one of the leading franchise operations of the Coca Cola Company in Kenya whose operations is typical to any other manufacturing industries has adapted to the effects of climate change by providing the trend of surface ozone in Nairobi over a period of years as an iceberg of the climate change and evaluating the effectiveness of the measures already adapted by the company.

2. THEORETICAL CONSIDERATIONS

The theoretical considerations were made with reference from [1,9]

The general equation for diesel combustion is given below.

$$4C_{12}H_{23} + 71O_2 \rightarrow 48CO_2 + 46H_2O \quad (1)$$

The general equation for diesel incomplete combustion is

$$2C_{16}H_{34} + 47O_2 \rightarrow 28CO_2 + 4CO + 34H_2O \quad (2)$$

2 mols of diesel fuel generates 4 moles of carbon monoxide; 1mol = 192g/mol of diesel; 1mol = 28g/mol of carbon monoxide; 2mols

= 384g/mol of diesel; 4mols = 112g/mol of carbon monoxide, thus 384g/mol of diesel generates 112g/mol of carbon monoxide.

$$\mathbf{X_d} = 0.29\mathbf{D}kg \quad (3)$$

The incomplete combustion equation for LPG combustion is given below

$$2C_3H_{8(g)} + 7O_{2\ (g)} \rightarrow 2C(s) + 2CO_{(g)} + 8H_2O_{(l)} + 2CO_{2(g)} \quad (4)$$

The amount of Carbon monoxide emitted during propane (LPG) combustion is 7.7lb/10^3gal propane (0.22kg CO/Kg Propane)

Thus, amount of carbon monoxide generated is

$$\mathbf{X_p} = 0.22\mathbf{P}kg \quad (5)$$

Total Carbon monoxide from LPG and diesel combustion

$$\mathbf{X_T} = \mathbf{X_d} + \mathbf{X_p} \quad (6)$$

Amount of surface Ozone equivalent

$$\mathbf{X_T} = (0.29\mathbf{D} + 0.22\mathbf{P})\mathbf{Kg} \quad (7)$$

The equation of ozone conversation from carbon monoxide is given below.

$$CO_{(g)} + 2O_{2(g)} + hv \rightarrow CO_{2(g)} + O_{3(g)} \quad (8)$$

The equation of ozone conversation from carbon monoxide is given below.

$$CO_{(g)} + 2O_{2(g)} + hv \rightarrow CO_{2(g)} + O_{3(g)} \quad (9)$$

28g/mol = 1mol of Carbon monoxide

Therefore, $\mathbf{X_T}$ Kg = $\frac{1000\ \mathbf{XT}\ g}{\frac{28g}{mol}}$ = 35.7$\mathbf{X_T}$ mols of carbon monoxide

1 mole carbon monoxide generates 1 mole of surface ozone as per equation

Thus 35.7XTmols of carbon monoxide equivalent 35.7$X_T$mols of Surface ozone
If 1mol = 48g/mol of surface ozone

Therefore, 35.7XTmols= $35.7\mathrm{XTmols} \times \frac{48g}{mols}$ = 1713.6g Surface ozone equivalent

C = 1.7136 $\mathbf{X_T}$Kg surface Ozone

C =1.7136(0.29D+0.22P) Kg surface ozone

Where:

C- the amount of surface ozone to be dispersed within Nairobi

D – Monthly amount of diesel consumed

P – Monthly amount of LPG consumed

X_d - being the monthly amount of carbon monoxide generated during diesel combustion

X_p - being the monthly amount of carbon monoxide generated during LPG combustion

X_T - total amount of carbon monoxide generated from LPG and Diesel combustion

C - monthly amount of surface ozone released by NBL operations

3. METHODOLOGY

The study area was in Nairobi specifically Nairobi Bottlers Limited. The Nairobi Meteorological Station was also facilitated in data collection. The period of data collected was between the January 2009 to June 2014.

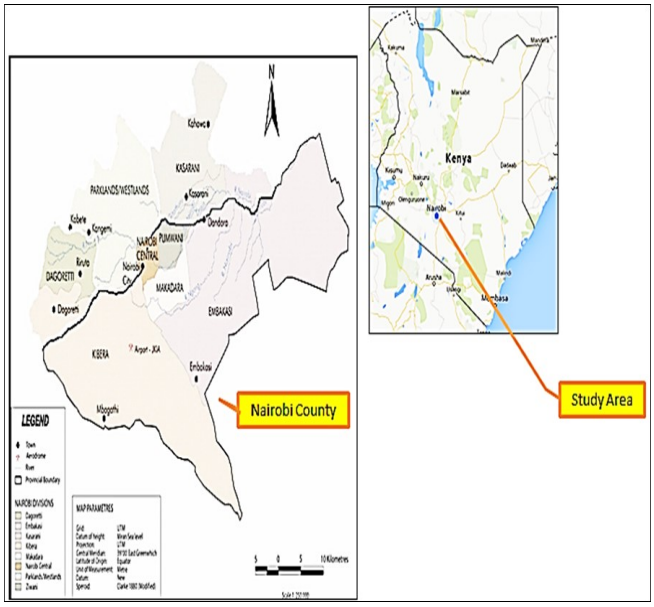

Figure 1: Map showing the study area

At the Nairobi Bottlers Limited the following data was collected: recordings of LPG consumed, Diesel consumed, water use ratio and energy use ratio for the period 2009 to 2013. The data was used to determine the Carbon foot print (kg/L) -amount of carbon dioxide generated (Kg)/ amount of beverage produced (L); Energy use ratio (J/L) - amount of energy consumed (J)/amount of beverage produced (L); and the Water use ratio (L/L) - amount of water consumed (l)/amount of beverage produced (L).

The surface ozone measurement was obtained from Meteorological station in Nairobi. The Ozone has two categories; vertical distribution of ozone and low ground level ozone. To determine the surface ozone measurement a balloon filled with hydrogen gas was released into the atmosphere with two equipment (which are calibrated before release) attached to it:

- Ozone zone – this is filled with a solution of Potassium iodite which reacts with surface ozone in the atmosphere generating electrical current, the higher the current the higher the ozone in the atmosphere
- Radiosonde – this measures the weather elements such as Temperature, Air pressure, Wind speed, wind direction and humidity

In order to determine how effective, the adaptation measures adapted by NBL to the effect of the climate change, this study reviewed the trend of **Energy Use Ratio - EUR** (diesel and LPG consumed) and **Water Use Ratio** (WUR).

Energy Use Ratio (J/L) = Amount of diesel and LPG consumed monthly/amount of beverage produced in litres. A downward trend indicates that the adaptation measures taken are bearing fruit.

Water use ratio (Kg/L) = Amount of water consumed monthly/amount of beverage produced in litres. A downward trend indicates that the adaptation measures taken are bearing fruit.

4. RESULTS AND DISCUSSIONS

4.1 Surface Ozone Calculated Between 2009 - 2014

The surface ozone calculated is represented in figure 2 below (the months are from Jan 2009 – representing month 1 while April 2014 representing month 64).

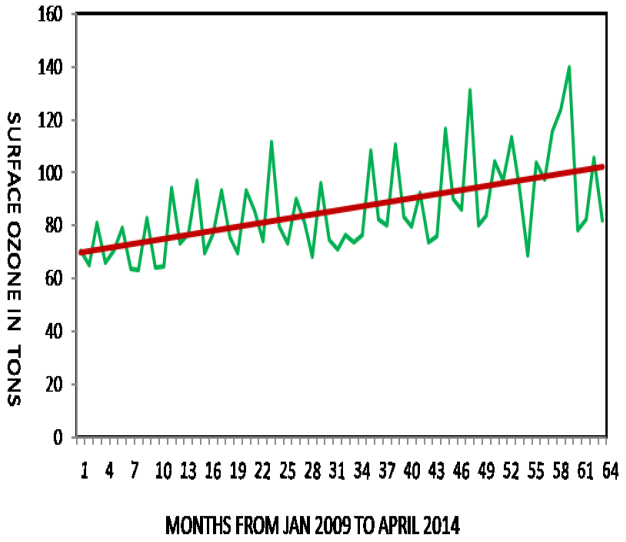

Figure 2: Calculated surface ozone equivalent between the periods of 2009 -2014

The trend of surface ozone in figure 2 is an increase in the surface Ozone calculated indicating there was a climatic change within the period under consideration. This also indicates that the amount of Carbon monoxide in the atmosphere also increased with the same period. The findings deductions concur with [10].

4.2 Surface Ozone measured between 2012 and 2014

This ozone measurement at the GAW (Global Atmospheric Weather) station was done every hour. This is captured in figure 3 below.

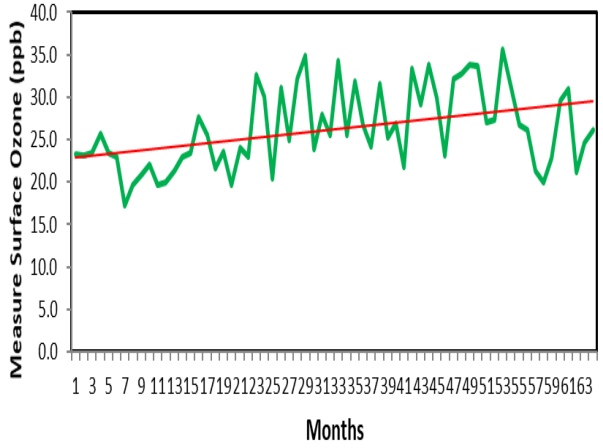

Figure 3: Shows the measured surface ozone between the periods of 2012 -2013

From figure 3, there is an upward trend indicating there was increase in the amount of surface Ozone measured inferring a climatic change within the period under consideration.

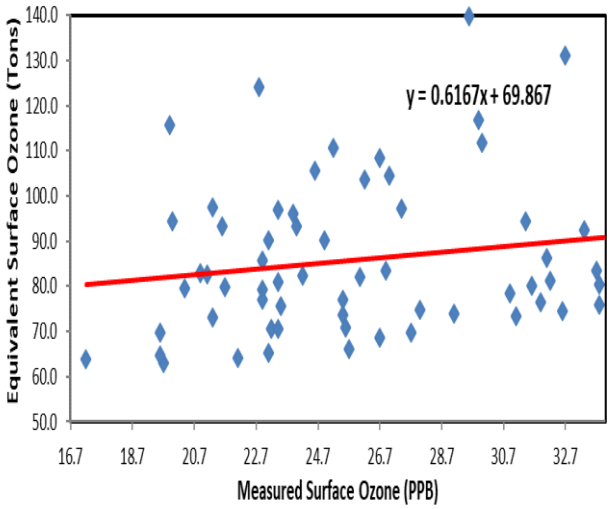

Figure 4: Climate change adaptation constants (Tons/PPB) 2012 -2013

From figure 4, there is a general upward trend for both Measured and Surface Ozone Equivalent for the period under review.

The effectives of the adaptation measures were evaluated by analysis of the data recorded within the bottling plant. The data for Energy Use Ratio (EUR) and Water Use Ratio were used. A downward trend graphs would indicate that the adaptation measures taken led to reduction in energy and water consumption thus the measures were effective. The recordings for the amount of water consumed (measured in Litres) to produces a litre of beverage commonly referred as Water Use Ratio (WUR) and the amount of energy (diesel and LPG and LPG) consumed referred as Energy ratio within the period produce a good trend.

1. Energy Use Ratio (J/L) = Amount of diesel and LPG consumed monthly/amount of beverage produced in litres. The company had a target to achieve a value of 0.5J/L.A downward trend indicates that the adaptation measures taken were bearing fruit.

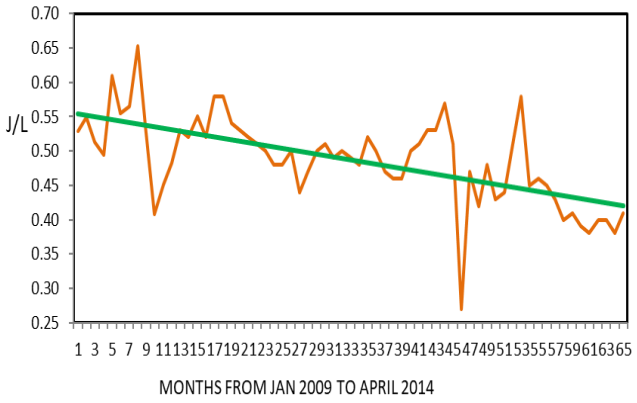

Figure 5: Shows Energy Use ratio between the periods of 2009 -2014

1. Water use ratio (Kg/L) = Amount of water consumed monthly/amount of beverage produced in litres. The company had a target to achieve a value 3.0 L/L. A downward trend indicates that the adaptation measures taken were bearing fruit. The use of plastic bottles other than glass bottles contributed to the reduction on the amount of water used to cleaned glass bottles before filling the bottles with beverage.

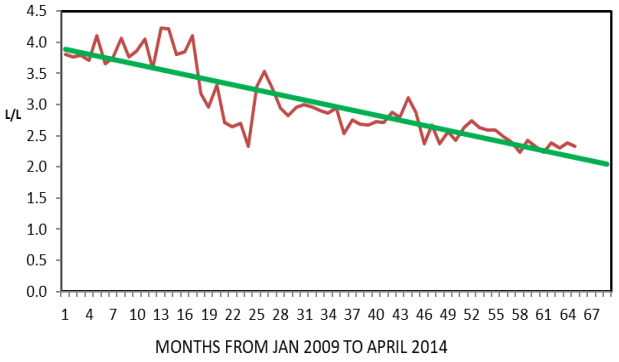

Figure 6: Water Use ratio between the periods of 2009 -2014

5. CONCLUSIONS

During the period of study, it was determined an upward trend in both Surface Ozone measured (at the meteorological station) and calculated equivalent surface ozone generated at NBL. Surface Ozone being one of the greenhouse gases influenced climate change within Nairobi County. The primary sources of greenhouse gases (Surface Ozone part of) identified during the study included Electricity consumption, Transportation, Manufacturing Industry, and Commercial and residential, Agriculture and Land use and forestry as a rule, minimum ozone values were observed in the morning and Maximum at noon.

The adaptation measures taken by NBL such the Source Water Protection Program (SWPP), Source Vulnerability Assessment (SVA), training staff on climate-change course and monitoring some of the climate change elements such as Energy Use Ratio (EUR) and Water Use Ratio (WUR) bore fruit in that the values of WUR and EUR dropped within the period of study. The values for WUR and EUR dropped within the period of study that is in the year 2009, the values were (WUR 3.8 and EUR 0.58) and they dropped to the year 2014 (WUR 2.3 and EUR - 0.41). This shows that the adaptation measures taken were effective. The use of plastic bottles other than glass bottles contributed to the reduction on the amount of water used to clean glass bottles before filling the bottles with beverage. This also led to reduction of energy used to distribute the beverages.

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