Carbon Footprint and Dairy Industry

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The Carbon Footprint (CF) is a measure of the total amount of CO_2 emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product (Wiedmann and Minx, 2007). Carbon foot print is a footprint of various activities which leads to emission of Green House Gases (GHGs). Thus, it is a measure of the GHGs and is measured in terms of CO_2 equivalent.

The environmental pollution has adverse effect on the living kingdom whether it be humans, cattle, rodents, aqua life and others. The recently encountered thunder storms of Kedarnath, Tsunamis, earth quakes, flood in Jamu and Kasmir, Hud Hud cyclone, global warming leading to melting of ice glaciers, increase in sea levels etc. are some of the detrimental effects. Many governments and various national and international agencies are working to reduce the effects of carbon emission and to have a green environment. The dairy sector is responsible for 2.7 % of global emission. In dairy sector, the emission starts from cropping the feed for milch animals to the consumption of milk products (Gerber *et al*., 2010). The various methods for measurement of carbon footprint as well as measures to control the carbon footprint are discussed (Beauchemin *et al.,* 2008*).*

Concept of Carbon Foot Print

The use of the term "footprint" is to describe the impact of industrial production or consumption activities. It was first developed by planners at the University of British Columbia (Wackernagel and Rees, 1996). The term "carbon footprint" originated from the ecological footprint concept. A carbon footprint focuses on processes and practices related to the emission of CO_2 and other greenhouse gases.

The term carbon footprint is commonly used to describe the total amount of CO_2 and other GHGs emissions through the life cycle of the product (Carbon trust, 2008; Wiedmann and Minx, 2007). A carbon footprint is often expressed as tons of CO_2 or tons of carbon emitted, usually on an annual basis (Growcom, 2008). The carbon footprint is broadly classified in two classes as primary and secondary footprint. The primary footprint is a measure of our direct emissions of CO_2 from the burning of fossil fuels including domestic energy consumption and transportation. The secondary footprint is a measure of the indirect CO_2 emissions from the whole lifecycle of products.

Green House Gases

The chemicals present in the atmosphere, termed as GHGs have certain radiation blocking properties which trap the sun's energy in the earth's atmosphere, creating a type of insulation. This leads to higher temperatures on earth than would otherwise occur. These GHGs are H_2O vapor, CO_2, CH_4, O_3, N_2O, Hydrofluorcarbons (HFCs), Perfluorcarbons (PFCs), Sulphur hexafluoride (SF_6) (Alfons, 2008). The latest report indicates that CO_2 level in the environment has reached to 402 ppm (Kiley, 2014). It is reported that if current rates of emission continue, the CO_2 concentrations are projected to reach a range of 535 to 983 ppm by the end of the 21st century (Gupta, 2012).

The emission of GHGs from various domestic and industrial activities are causing global warming. This has led to variation in season and landscapes, rising sea level, stronger storms, increase in heat related illness and diseases. Reduction of GHGs emissions will aid in protecting ourselves, economy and adverse climatic changes (Roger and Brent, 2007). The records of surface temperature over the last century show that there has been a gradual increase in average temperature around the word

Effect of Energy Use on Carbon Footprint

Energy used is the main cause of emissions of GHGs at the processing and transportation stages. The reduction of energy consumption by 1 kilowatt hour saves 3 kWh of primary energy, which comes mainly from fossil fuels. Improving energy efficiency, a conversion to renewable energy systems causes a dramatic reduction in GHGs. The world average energy consumption is equivalent to 2.2 tons of coal (Desai *et al*., 2010). In India coal meet 50% of commercial energy requirement, oil accounts for 36% of energy consumption and natural gas accounts for 8.9% of energy consumption. Green house gases emission from electricity generation using different sources of energy are listed below.

Energy source	kg CO_2 / MWh
Coal or oil	1030
Natural gas	622
Anaerobic digester	46
Solar PV	39
Nuclear	17
Wind	14

Carbon Footprint and Milk Industry

Agriculture today is one of the main reasons why three planetary boundaries (climate change, biodiversity loss and changes in the global nitrogen cycle) have already been transgressed (Rockstromer *et al.,* 2009). It is found that largest share of the GHGs emissions occurs before farm gate (Flysjo, 2012).

The most important GHGs generated by dairy industry are methane, nitrous oxide, carbon dioxide and some refrigerants such as HFCs and CFCs (Vora, 2010). The major source of CH_4 emission is due to enteric fermentation of animals (Hospido, 2005). Nitrous oxide (N_2O) emission is due to production and use of fertilizer, manure storage. Carbon dioxide (CO_2) emission occurs due to use of energy at farm level as well as processing level (Thomasen *et al*., 2008).

There are two main sources of GHGs at the manufacturing level which are given below.

- Process energy consumption
- Fossil fuel consumption for transport

Emission of CFCs and HFCs refrigerant gases from the refrigerating system in the factory may occur in case of leakage from the system. The other important sources of emission are the waste management and packaging of dairy products. Indirect emission outside the dairy plant site occurs due to transportation involved in collection of milk and delivery of products (Vora, 2010).

Dairy products are associated with GHGs emissions so as the case for almost all the food products. The demand for dairy products is predicted to be double by 2050 which requires higher production of milk and energy for processing and manufacture of different products. Therefore, it is very important to increase the productivity of our milch animals and to process the milk with minimum use of energy. The process re-engineering, use of renewable energy and optimization of various dairy plant operations are key to reduce the carbon foot print. These challenges can be well addressed by involving effective policy making, R&D work and management at national and international level.

Calculation of Carbon Footprint

The importance of calculation of CF is not only for manufacturers but also to the consumer of the products. The importance of calculation of CF reported by are indicated below (ISO, 2006 a, b).

- Identification and reduction of GHG
- Creating a benchmark to monitor
- Identifying cost saving opportunities
- To prepare for possible future effects and national or international policy initiatives
- Integrating GHG emissions into decision making
- Enabling positive marketing and branding
- Empowering consumers to select products with lower product carbon footprint
- Demonstrating environmental responsibility leadership to both stakeholders and Consumers

Life Cycle Assessment (LCA) method is used for the calculation of carbon footprint. LCA methods have been developed by International Organisation for Standardization (ISO), and focuses on the quantification of a range of environmental impacts,

including climate change, across the whole life of a product - from extraction or growing of raw materials, through product manufacture to use and final disposal. LCA is a structured, comprehensive, and internationally standardized method which involves various steps (Aumonier, 2008).

- Describe the product used by the customer
- Construct the map diagram of all activities
- Annotate the diagram with various detail regarding activities
- Indentify CO_2 equivalent factors
- Identify CO_2 equivalent emission factors for the combustion of fuels.
- Identify non-combustion-related emission factors
- Balance the product map drawn up
- Multiply CO_2 equivalent factors by quantities of inputs and outputs
- Documentation
- Verifying

CF calculations are typically based on annual emissions from the previous 12 months based upon the life cycle of products.

Kyoto Protocol

The Kyoto protocol is a protocol to the United Nation Framework Convention on climate Change (UNFCCC), aimed at fighting global warming. It is for achieving stabilization of GHGs concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The Protocol was initially adopted on 11, December 1997 in Kyoto, Japan and entered into force on 16 February, 2005. The protocol has been signed by 187 states (Sheth, 2010). Total number of parties under this protocol is 192. In them 40 are under Annex I, 23 are under Annex II and other are non Annex countries. The protocol allows several flexible mechanisms such as emissions trading, the clean development mechanisms and joint implementation. India signed and ratified the protocol in 26 August, 2002. India is coming under non annex countries.

Reduction of Carbon Footprint in Dairy Sector

The variation in GHGs emissions among dairy farms indicates that there is a potential to reduce the CF (Cederberg *et al*., 2004). CH_4 from enteric fermentation is by far the largest single contributor to the CF of milk at farm level (Beauchemin *et al*., 2008). Increasing the quality of feed, especially roughage, can reduce enteric CH_4 production (Danielsson, 2009). Less use of fertilizer and use of manure for biogas production can also reduce carbon footprint (Holm-Nielsen *et al*., 2009; Agus, 2011). Synthetic fertiliser (ammonium nitrate) produced with BAT has about half the CF compared to a traditionally produced (Jenssen and Kongshaug, 2003). Optimizing protein feeding can reduce nitrogen emission (Greppa, 2008).

Use of alternative energy sources like solar energy, biogas from effluent treatment plant, biomass energy, biomass gassifier (Rathore, 2010) can reduce CF. Reduction in transportation energy, optimum use of packaging material and selection of fuel have great potential to reduce the CF (Berlin and Sonesson, 2008).

Energy Conservation in Dairy Plants

Refrigeration is a major energy consuming utility in dairy plants. It is estimated that electricity consumption of refrigeration plant is about 50-60% of total electrical consumption. The important factors that affect the performance of vapor compression refrigeration system, include evaporating temperature, condensing temperature, sub-cooling of liquid refrigeration system, super heating of suction gas, presence of non condensable gases, volumetric efficiency of compressor etc. Operation of electrical motors at optimum load is very important to get higher efficiency of motor. It is also recommended to avoid repeated rewinding of motors because rewinding leads to 5% efficiency loss. Generation of steam in boilers under optimized conditions, selection of fuel, efficient use of steam produced and recovery of condensate are key factors for the conservation of thermal energy. Water is essential service in dairy plant for many activities. It is necessary to reduce water consumption not only to reduce the pumping cost but also to reduce load on effluent

treatment plant. Dairy industry is facing challenge of cost competitiveness, energy conservation and technology up gradation. The following technology up gradation can contribute to reduction of energy consumption.

It is reported that total waste of milk and dairy products at consumer level corresponds to approximately 63 Mt CO_2e globally (Gustavsson *et al*., 2011). Extension of shelf-life of products and avoiding food waste helps in reducing GHGs in post dairy chain (Wrap, 2009).

Standards for Product Carbon Footprint

There are various standards for carbon footprint and there are labels of different standards which are given on the product pack (ITC, 2012). The International Dairy Federation (IDF) has developed a common carbon foot printing approach for the dairy sector including milk production and processing. The guide aims to provide a harmonized approach to calculate the product carbon footprint (PCF) of milk and milk products.

Carbon Zero Programme

The Carbon Zero Programme was developed by Landcare Research to measure, manage and mitigate GHGs and direct energy use for businesses, households and individuals (Carbon Zero, 2007; Smith *et al*., 2006). Carbon neutral refers to achieving net zero carbon emission by balancing a measured amount of carbon released with an equivalent amount offset, or buying enough carbon credits to make up the difference. The programme has led to many carbon-neutral dairy and food products.

Conclusion

An increase in the GHGs emission is noticed each day due to increased population, consumption patterns, production volumes and biggest of all is the ignorance about the detrimental effects of these emitted gas on our life and our future generations. The dairy sector now has a methodology that will allow the calculation of carbon footprint of dairy products. The International Dairy Federation wanted to build a tool to help the dairy sector to identify, quantify and evaluate emissions. The main objective of CF calculation is to build an action plan to reduce GHGs emissions. In order to reduce GHGs emission from dairy sector, it will be crucial to transfer the knowledge to dairy farmers, optimize farming system, reduce the energy consumption and proper management of waste.

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