Journal of Cleaner Production 188 (2018) 888–899

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

New method to calculate water ecotoxicity footprint of products: A contribution to the decision-making process toward sustainability

Rita de Cássia Monteiro Marzullo [a,*], Patricia Helena Lara dos Santos Matai [b], Dione Mari Morita [c]

[a] Laboratory of Life Cycle Assessment, Institute of Energy and Environment, University of São Paulo (USP), São Paulo, Brazil
[b] Department of Mines and Petroleum, Polytechnic School/USP, São Paulo, Brazil
[c] Department of Hydraulic and Environmental Engineering, Polytechnic School/USP, São Paulo, Brazil

ARTICLE INFO

Article history:
Received 5 December 2016
Received in revised form
30 March 2018
Accepted 30 March 2018
Available online 6 April 2018

Keywords:
Sustainability
Life Cycle Assessment
Water footprint
Eco-labeling
Local impacts
Industrial effluents
Environmental indicator
Water ecotoxicity footprint

ABSTRACT

Sustainability depends on the adoption of attitudes by the productive sector to achieve cleaner production processes. Earth provides the resources necessary for life, but the anthropic concept of survival is inserted in acts of consumption and production to meet the demand that hinder the achievement of sustainability itself. On the other hand, both the supply chain and the end consumer need information which may assist decision-making about buying products that do not harm the environment. The conscious consumption is a growing practice worldwide and manufacturers should adopt a proactive approach to monitor pollution and the impacts caused by their products. Aquatic ecotoxicity can affect multiple trophic levels, compromising water quality for both human consumption and ecosystems biodiversity. Since water is an essential resource for life, this study proposes a method for calculating the Water Ecotoxicological Footprint of products and presents an illustrative example of application to achieve a single indicator that can be used in comparative assessments or benchmarking. Obtained by quantifying tangible variables in a system of monitoring, management of water use and disposal of effluent (wastewater) in industrial and agricultural environments, this indicator aims to contribute to the decision-making process towards sustainability since it may be showed as an informative label on the packaging of each product answering the question: “How much does this product contribute to the aquatic ecotoxicity?” or “How much does this product contribute to the loss of biodiversity?”. From a product life-cycle perspective, the spatial and temporal dimensions were inserted by using a geographic information system (GIS) for local assessments. Public policies can be established to encourage the identification and mitigation of aquatic ecotoxicity impact throughout the product supply chain.

1. Introduction

In a complex society, with a growing population, the supply of demands for food and infrastructure/services is essential to guarantee a better quality of human life; however, this supply puts pressure on the environment. It is estimated that 60% of natural resources have been degraded or are used unsustainably (Millennium Ecosystem Assessment, 2005).

Water is an essential natural resource for life and the preservation of its quality is fundamental in the context of sustainability to the vast majority of international organizations and groups, including those with a mandate focused on economic development.

We are in the ecological era and industries should consider the green brand equity, investing more resources in green brand image, green satisfaction, and green trust (Chen, 2010). However, the transition to a green economy requires the adoption of specific policies by each region/country so that it is not optional but extremely necessary, as there is already a consensus and acceptance that environmental degradation is a major threat to economic growth. The investment in the environment increases productivity, protects the stock of resources and boosts economic growth (ILO, 2013).

With the advent of global concern about climate changes, researches for the replacement of non-renewable energy by

* Corresponding author.
E-mail address: rita.monteiro.usp@gmail.com (R.C.M. Marzullo).

https://doi.org/10.1016/j.jclepro.2018.03.307
0959-6526/

renewable one have increased in recent decades (EIA, 2013a, b).

Blottnitz and Curran (2007) reviewed the assessments conducted on bioethanol as renewable transportation fuel and concluded that all the bioethanol production “is mildly to strongly beneficial from a climate protection and a fossil fuel conservation perspective”. However, our need for a sustainable transportation fuel should also consider the impact on water resources. Every organism needs water to live; therefore, the water aware issue is thus a prerequisite for sustainability.

The substitution of petroleum-based gasoline for bioethanol, for example, has the potential to change many environmental impacts related to land and water use in several communities. We need to improve our understanding of trade-offs associated with bioenergy expansion and footprinting indicators can help it.

With global climate change, rainfall levels are changing gradually and some regions of the planet are getting drier while other areas are becoming wetter. Since water is distributed unequally, this fact issues a warning sign regarding water supply, now and in the future. Water shortages hinder the growth of several economic activities, sacrificing industry, power generation, human consumption and agriculture, which are increasingly competing for water in a setting that can seriously affect food security (Lozan et al., 2007).

The presence of pollutants in the aquatic environment cause long term effects in population level at the endpoints. These effects can be evaluated through experiments in the several generations (Muyssen and Janssen, 2004). The discharges of pollutants into the environment and the global forecasted temperature increase have caused a permanent reduction of the biodiversity in aquatic ecosystems (Sala et al., 2000; Thuiller, 2007).

There are several possible sources of contamination of water bodies: inadequate disposal of effluents or solid waste from industries, mining operations, runoff with pesticides and fertilizers in agricultural areas, among others. Besides, new chemicals are emerging at an accelerated rate in the market and their impacts on the environment and on human beings are still unknown (Morita, 2010). Therefore, the simple control on the discharge of few chemicals in water bodies does not protect the aquatic environment.

Ecotoxicity can be an indicator to evaluate the level of conservation of living biota and the integrity of the environmental services provided by it. According to Wenzel et al. (1997), some chemicals have toxic effects when released into water bodies in concentrations that affect living organisms, the function and structure of aquatic or terrestrial ecosystems.

Ecotoxicity represents not only the result of the effects of isolated substances, but also the interaction between them in a given environment, disturbing the existing balance between organisms. Synergistic, additive and antagonistic interactions that can increase or reduce the harmful effects on aquatic organisms should be considered. Industrial and agricultural effluents represent the major contributions as toxic loads into watersheds and thus, the importance to determine their ecotoxicity to the water bodies is evident (Zagatto and Bertoletti, 2008).

This paper provides a contribution to sustainability by a proposal of a new method for obtaining a Water Ecotoxicity Footprint (WEF) indicator of products. This indicator is obtained by quantifying tangible variables in a water usage monitoring system in industrial and agricultural environments.

Besides obtaining a water usage indicator per volume, understanding the impact of ecotoxicity on aquatic environments, as an indicator of “footprint” or “footprinting”, is an essential stage in the development of strategies to reduce and to mitigate these impacts with cleaner production processes. Thus, this work is motivated by the challenge of answering the following question to the end consumer:

> “*What is the real contribution of the product to aquatic ecotoxicity?*”

This method allows an answer to this question in an eco-labeling process. Gen (2015) defines eco-labeling as a voluntary method which identifies overall environmental performance of a product or service based on life cycle considerations.

According to DSouza (2000), environmental labels are used by business to communicate the environmentally friendly message to consumers and they can use it as a guide to choose environmentally friendly products.

The International Organization for Standardization (ISO) divided environmental labeling in three types: type I includes multi-criteria third-party programs intended to end consumers; type II involves self-declared environmental claims, and type III provides quantified environmental data in environmental product declarations based on Life Cycle Assessments Standard (ISO 14020:2000; ISO 14024:1999; ISO 14025:2006; ISO 14040:2006).

According to the World Trade Organization's “Code of Good Practice” (WTO, 2015), technical regulations, standards and procedures for conformity assessment may not be prepared, adopted or applied with the intention of creating obstacles to international trade. Therefore, as Rubik and Frankl (2005) suggested, environmental product information, such as eco-label, needs to be linked to national and international government policies.

2. New method framework proposal

This work began with the challenge of using the Life Cycle Assessment method (LCA) perspective to calculate the Water Ecotoxicity Footprint (WEF) of products considering the spatial and temporal dimensions. Although the LCA method is considered and recognized as being particularly useful in sustainability assessments, it must be supported with more site-specific tools that can more appropriately address issues such as land use and water use (Bare, 2014).

Starting from a critical appraisal of the LCA method, it was possible to propose a new method that is an association between the guidelines in the standards in LCA (ISO 14040 and ISO 14044), the standard regarding water footprint (ISO 14046) and the impact assessment method suggested by USEPA (1985) and used by CETESB (2013). The geographical variable is added for the evaluation of the local impact by employing the Geographic Information System (GIS).

The name “*Water Ecotoxicity Footprint* “ (WEF) is aligned with the new ISO 14046 standard, which recommends always adding a qualifier to the name “water footprint” (e.g., water availability footprint, water eutrophication footprint or water ecotoxicity footprint). The same standard also mentions that the name “water footprint” may only be used alone if the assessment comes from an LCA with a complete and comprehensive approach, including the largest possible number of impact categories at the midpoint or end point.

The proposed method is based on LCA phases, adding preliminary Macro and Micro evaluations to the scope of the study with the inclusion of local geographic variables. Several studies underline the importance of spatial and temporal appropriate scale