LCA APPLIED TO RESIDUAL ORGANIC FERTILIZING MATERIALS – AN OVERVIEW OF SUBSTITUTION METHODOLOGICAL OPTIONS AND QUANTITATIVE SUBSTITUTION RATES

Marilys Pradel, Irstea, UR TSCF, Domaine des Palaquins, 40 route de Chazeuil, 03150 Montoldre, France
marilys.pradel@irstea.fr
Claire Déchaux, Irstea, UR OPAALE, 17 avenue de Cucillé – CS 64427, 35044 Rennes Cedex, France / Univ Bretagne Loire, France

Key Words: state of the art, LCA, substitution, residual organic fertilizing materials, mineral fertilizers

LCA case studies applied to waste management options of organic products face several LCA methodological choices and among them, the multifunctionality question. Indeed, studies dealing with waste management aim to assess the environmental impacts of different organic waste treatments that enhance the organic waste fertilizing and amending properties. This is expressed in LCA studies by a primary function (to treat the waste) and secondary functions (to fertilize or provide an organic amendment to agricultural soils).The induced multifunctionality is often treated by system expansion by subtracting the secondary functions, leading to potentially avoided impacts. When dealing with residual organic fertilizing materials, scientific papers are used to substitute the function “fertilizing with organic wastes” by an alternative function “fertilizing with mineral fertilizers”. Occasionally, the function “amending with organic wastes” can be substituted by an alternative function “amending with peat”. This paper aims to present the results of a literature review dealing with methodological choices and quantitative rates to substitute residual organic fertilizing materials (digestates, composts issued from various substrate origins: sludge, crop residues, manure…) with mineral fertilizers.

Based on a corpus of 132 peer-reviewed papers dealing with LCA case studies of residual organic fertilizing materials including land spreading, a set of 41 papers detailing system expansion by subtraction (substitution) was selected among this corpus. Those selected papers were used to state how the authors solve the above-mentioned multifunctionality problem and to highlight the quantitative rates to substitute residual organic fertilizing materials with mineral fertilizers.

The literature review highlights nine different forms to consider substitution. In most of these papers, substitution is based on the fertilizing potential[1] of the residual organic fertilizing material and/or on its utilization rate based on the nutrient availability[2] (referred later on as substitution coefficient). Regarding P and K, the substitution coefficients are often close and most of the papers consider a 100% substitution coefficient whatever the organic waste. The substitution coefficient for N ranges 20 to 30% for compost and 40 to 90% for digestate. These range differences depend on the substrate origin, the type of treatment and its performances. When considering the alternative function (i.e. to fertilize with mineral fertilizers), most of reviewed papers only take into account the mineral fertilizer production but do not consider their transport, spreading operation and spreading emissions. The main mineral fertilizers substituted are ammonium nitrate for N, superphosphate or triple superphosphate for P and potassium chloride for K.

Whereas the 41 case studies of the review have different system boundaries, functional units and hypothesis, the impact on the results of the substituted mineral fertilizers can be barely compared between the studies. The impact of substitution is not significant in most of the case studies; however some authors highlight a significant contribution of the substituted mineral fertilizers. This is pointed out regarding mainly climate change, acidification and eutrophication, and generally these impacts are respectively caused by the N_2O, NH_3, nitrate and phosphate emissions of the potentially avoided spread mineral fertilizers. Therefore, the way system expansion is led has a decisive influence on results. Impacts on smog, particulate matter formation, toxicity, ecotoxicity, resources, ozone layer depletion and primary energy barely emerged.

The review led to an overview of the LCA habits when considering substitution of residual organic fertilizing materials used as agricultural fertilizers. It pointed out the need to superimpose the boundaries of the substituted activities. The way authors deal with the N, P and K content of digestates has been examined, leading to an overview of substitution practices. It has also been demonstrated that the most often substituted mineral fertilizers reflect the most often sold mineral fertilizers. Thus, conclusions of the literature review led to recommendations for practitioners using LCA in the organic waste management field.

[1] Defined as the amount of N, P and K (g/kg) contained in the residual organic fertilizing material
[2] Defined as the availability of nutrients to be taken up and used by living biological organisms (agricultural crops)