The Life cycle Assessment of Sugarcane: A case study of Amir Kabir Cultivation & Industry

La evaluación del ciclo de vida de la caña de azúcar: un estudio de caso de Amir Kabir Cultivation & Industry

A avaliação do ciclo de vida da cana-de-açúcar: um estudo de caso do cultivo e indústria de Amir Kabir

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ABSTRACT

Assessing life cycle is widely used for estimating energy consumption and environmental loads of goods and services. One of applications of this method is to assess the environmental effects of food products. Due to high demand for sugar in Iran market, the role of sugarcane is very significant in Iran sugar supply. The aim of this study is to assess environmental effects of producing a tone of sugar in Amir Kabir cultivation and industry in Khuzestan. Based on ISO standard, five classes of environmental effects were assessed including Abiotic depletion, eutrophication, acidification, global warming and ozone layer depletion according to the CML method. The data of current study has been collected of Amir Kabir cultivation and industry through in person interview as well as questionnaire in 2015. Background data has been extracted from eco-invent database. Based on the results for eutrophication 4.6 kg PO4---, acidification potentials 94.91 kg SO2, global warming 1701.76 kg equivalent carbon dioxide and abiotic depletion 0.000087 kg Sbeq and ozone layer depletion 28 milliliters of CFC are released into the environment. The

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results indicated that producing sugarcane, electricity and burning herbal remnantswere the main contributors to the abovementioned effect classes for per ton of sugarcane.

Keywords: Environmental Effects ,Sugarcane, Global Warming, Acidification, Abiotic Depletion.

RESUMEN

La evaluación del ciclo de vida se usa ampliamente para estimar el consumo de energía y las cargas ambientales de bienes y servicios. Una de las aplicaciones de este método es evaluar los efectos ambientales de los productos alimenticios. Debido a la alta demanda de azúcar en el mercado de Irán, el papel de la caña de azúcar es muy importante en el suministro de azúcar de Irán. El objetivo de este estudio es evaluar los efectos ambientales de producir un tono de azúcar en el cultivo y la industria de Amir Kabir en Khuzestan. Con base en el estándar ISO, se evaluaron cinco clases de efectos ambientales que incluyen agotamiento abiótico, eutrofización, acidificación, calentamiento global y agotamiento de la capa de ozono de acuerdo con el método CML. Los datos del estudio actual se han recopilado del cultivo y la industria de Amir Kabir mediante una entrevista en persona y un cuestionario en 2015. Los datos de contexto se han extraído de la base de datos de eco-invent. Basado en los resultados de eutrofización 4.6 kg PO4 ---, potenciales de acidificación 94.91 kg SO2, calentamiento global 1701.76 kg dióxido de carbono equivalente y agotamiento abiótico 0.000087 kg Sbeq y agotamiento de la capa de ozono 28 mililitros de CFC son liberados al medio ambiente. Los resultados indicaron que la producción de caña de azúcar, electricidad y quema de restos de hierbas fueron los principales contribuyentes a las clases de efectos mencionadas anteriormente por tonelada de caña de azúcar.

Palabras clave: Efectos Ambientales, Caña de Azúcar, Calentamiento Global, Acidificación, Depleción Abiótica.

ABSTRATO

A avaliação do ciclo de vida é amplamente utilizada para estimar o consumo de energia e as cargas ambientais de bens e serviços. Uma das aplicações deste método é avaliar os efeitos ambientais dos produtos alimentícios. Devido à alta demanda por açúcar no mercado iraniano, o papel da cana-de-açúcar é muito significativo no suprimento de açúcar do Irã. O objetivo deste estudo é avaliar os efeitos ambientais da produção de um tom de açúcar no cultivo de Amir Kabir e na indústria em Khuzestan. Com base no padrão ISO, foram avaliadas cinco classes de efeitos ambientais, incluindo depleção abiótica, eutrofização, acidificação, aquecimento global e depleção da camada de ozônio de acordo com o método CML. Os dados do estudo atual foram coletados do cultivo e da indústria de Amir Kabir por meio de entrevista presencial e questionário em 2015. Os dados de base foram extraídos do banco de dados de invenções ecológicas. Com base nos resultados de eutroficação 4,6 kg PO4 ---, potenciais de acidificação 94,91 kg SO2, aquecimento global 1701,76 kg dióxido de carbono equivalente e depleção abiótica 0,000087 kg Sbeq e depleção da camada de ozônio 28 mililitros de CFC são liberados no meio ambiente. Os resultados indicaram que a produção de cana-de-açúcar, eletricidade e queima de restos de ervas foram os principais contribuintes para as classes de efeito supracitadas para a tonelada de cana-de-açúcar.

Palavras-chave: Efeitos Ambientais, Cana-de-açúcar, Aquecimento Global, Acidificação, Depleção Abiótica.

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INTRODUCTION

The sustainability of food systems over the recent years has been of a great importance according to the policy makers (Garnett, 2014; Ericksen, 2008). The policy makers face with internal challenges of increasing food production and reducing the use of resources and environmental effects (Soussana, 2014). So that almost 20 to 35% of energy consumption of the world is dedicated to food production system (including agriculture production, industrial processing, warehousing, distribution and use) (Sanjuan et al, 2014; Hertwich and Peters, 2009). Hence; 20 to 30% of environmental effects in the world is related to food production (Tukker and Jansen, 2006). In terms of increasing population and simultaneously with increasing demand, a transition to agricultural and sustainable food production system is necessary. Numerous studies have proved the need for excessive efforts to perceive the environmental interactions of food production activities (Garmnett, 2014; Soussana, 2014; Ericksen, 2008). These environmental interactions occur in several levels in terms of time and space. Inter-field approaches and combination of attitudes (in terms of production efficiency, changing consumption etc.) should be used to assess environmental interactions between food production activities. LCA is a method which is used to assess environmental effects associated with a product or a specific process based on calculating the two components of the amount of resource consumption and the emission of various pollutants to the environment (Brentrup et al., 2004 a; Roy et al., 2009; Van Zeijts et al., 1999). The case studies, using these system analyses, can play a pivotal role in determining

INTRODUCCIÓN

La sostenibilidad de los sistemas alimentarios en los últimos años ha sido de gran importancia según los responsables de las políticas (Garnett, 2014; Ericksen, 2008). Los formuladores de políticas enfrentan los desafíos internos de aumentar la producción de alimentos y reducir el uso de recursos y los efectos ambientales (Soussana, 2014). De modo que casi del 20 al 35% del consumo de energía del mundo está dedicado al sistema de producción de alimentos (incluida la producción agrícola, el procesamiento industrial, el almacenamiento, la distribución y el uso) (Sanjuan et al, 2014; Hertwich y Peters, 2009). Por lo tanto; Entre el 20 y el 30% de los efectos ambientales en el mundo están relacionados con la producción de alimentos (Tukker y Jansen, 2006). En términos del aumento de la población y, al mismo tiempo, del aumento de la demanda, es necesaria una transición al sistema de producción de alimentos agrícola y sostenible. Numerosos estudios han demostrado la necesidad de esfuerzos excesivos para percibir las interacciones ambientales de las actividades de producción de alimentos (Garmnett, 2014; Soussana, 2014; Ericksen, 2008). Estas interacciones ambientales ocurren en varios niveles en términos de tiempo y espacio. Los enfoques entre campos y la combinación de actitudes (en términos de eficiencia de producción, consumo cambiante, etc.) se deben usar para evaluar las interacciones ambientales entre las actividades de producción de alimentos. LCA es un método que se utiliza para evaluar los efectos ambientales asociados con un producto o un proceso específico basado en el cálculo de los dos componentes de la cantidad de consumo de recursos y la emisión de diversos contaminantes al medio ambiente (Brentrup et al., 2004 a; Roy et al., 2009; Van Zeijts et al., 1999). Los estudios de casos, utilizando estos análisis de sistema, pueden jugar un papel fundamental en la determinación de

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these interactions. Standard World Organization has proposed the standard of ISO 14040 as a framework for managing agricultural production systems sustainability. Assessing life cycle includes inputs and outputs of the manufacturing systems and evaluates the related potential effects to that during product lifecycle. Nowadays such information about environmental effects of various products lifec ycle greatly contribute the decision makers of this field (ISO 14040, 2006). Various studies have been conducted about life cycle assessment to identify hot environmental points of agricultural production. Meisterling et al., by calculating LCA for wheat and bread production systems under the current organic and conventional management in the United States in terms of global warming potential, showed that the production of one kilogram of bread in the organic system compared to the conventional system, produces less carbon dioxide by 30 kilograms (Meisterling et al., 2009). Brentrup et al, by studying the environmental effects of different amounts of nitrogen fertilizer in winter wheat production systems in Germany, using LCA, reported at low levels of nitrogen fertilization land use change and at high levels eutrophication was the controlling factor for LCA (Brentrup et al., 2004b). Monti et al. assessed the LCA and concluded by replacing perennial plants in common agronomic systems, the environmental effects of carbon dioxide and nitrate leaching can be reduced by more than 50 percent (Monti et al., 2009). Kanals et al., by studying environmental effects of economic products on the organic matter content of the soil, also suggested that the LCA method is an appropriate indicator for evaluating production systems (Cannals et al., 2007). Nie et al. (2010), studying the effects of multiple cropping and single-cropping systems, stated that multiple cropping reduced the harmful effects of

estas interacciones Standard World Organization ha propuesto el estándar de ISO 14040 como un marco para gestionar la sostenibilidad de los sistemas de producción agrícola. La evaluación del ciclo de vida incluye las entradas y salidas de los sistemas de fabricación y evalúa los efectos potenciales relacionados a eso durante el ciclo de vida del producto. Hoy en día, dicha información sobre los efectos ambientales de diversos productos de vida contribuyen en gran medida a quienes toman las decisiones en este campo (ISO 14040, 2006). Se han llevado a cabo varios estudios sobre la evaluación del ciclo de vida para identificar puntos ambientales candentes de la producción agrícola. Meisterling et al., Al calcular LCA para sistemas de producción de trigo y pan bajo la actual gestión orgánica y convencional en los Estados Unidos en términos de potencial de calentamiento global, mostró que la producción de un kilogramo de pan en el sistema orgánico en comparación con el sistema convencional , produce menos dióxido de carbono en 30 kilogramos (Meisterling et al., 2009). Brentrup et al, mediante el estudio de los efectos ambientales de diferentes cantidades de fertilizante de nitrógeno en los sistemas de producción de trigo de invierno en Alemania, usando LCA, informaron a bajos niveles de cambio fertilización uso de la tierra de nitrógeno y en niveles altos eutrofización era el factor de control para LCA (Brentrup et al., 2004b). Monti et al. evaluó el ACV y concluyó reemplazando plantas perennes en sistemas agronómicos comunes, los efectos ambientales del dióxido de carbono y la lixiviación de nitratos se pueden reducir en más del 50 por ciento (Monti et al., 2009). Kanals et al., Al estudiar los efectos ambientales de los productos económicos sobre el contenido de materia orgánica del suelo, también sugirieron que el método LCA es un indicador apropiado para evaluar los sistemas de producción (Cannals et al., 2007). Nie et al. (2010), al estudiar los efectos de los sistemas de cultivo múltiple y de monocultivo, afirmó que el cultivo múltiple reducía los efectos nocivos de

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production on the environment (Nie et al., 2010). Brentrup et al., believe that calculating LCA can even identify the problems in the processes of the production system, such as resource consumption and land use change (Brentrup et al., 2001). In order to investigate different LCA groups in agricultural activities, the environmental effects of direct and indirect consumption of various activities should be considered (Brentrup et al., 2002b; Brentrup et al., 2004a).

In rapeseed production Life Cycle Assessment in Mazandaran province and determining the amount of emissions of environmental pollutants, nitrogen and diesel fuel were the most important inputs of energy consumers. Similarly, the analysis of environmental indicators showed that the highest levels of pollution are associated with three non-organic respiratory indicators, global warming, and nonrenewable energy consumption (Mousaviavval et al., 2015). In the study of energy flow and environmental impacts, greenhouse production of medicinal plants with a lifecycle assessment approach, heating, and greenhouse structure account for more than 90% of energy consumption. (Khanali&HosseinzadehBndbafha, 2017).Investigating the environmental effects of water rain fed wheat production systems in Iran using life cycle assessment, the most and least environmental effects in water wheat production system were respectively obtained for the effect groups of global warming and eutrophication of watering system (Khoramdel et al, 2014) while in rain fed wheat production system, the effect groups related to water eutrophication and acidification. These researchers estimated the range of environmental index of watering and rain fed wheat production systems respectively as 0.47-0.55 and 0.34-0.43 per ton of grain.

producción en el medio ambiente (Nie et al., 2010). Brentrup et al. Creen que el cálculo de la ECV puede incluso identificar los problemas en los procesos del sistema de producción, como el consumo de recursos y el cambio en el uso de la tierra (Brentrup et al., 2001). Para investigar diferentes grupos de ACV en actividades agrícolas, se deben considerar los efectos ambientales del consumo directo e indirecto de diversas actividades (Brentrup et al., 2002b, Brentrup et al., 2004a).

En la producción de colza Evaluación del ciclo de vida en la provincia de Mazandarán y la determinación de la cantidad de emisiones de contaminantes ambientales, el nitrógeno y el combustible diesel fueron las aportaciones más importantes de los consumidores de energía. Del mismo modo, el análisis de los indicadores ambientales mostró que los niveles más altos de contaminación están asociados con tres indicadores respiratorios no orgánicos, el calentamiento global y el consumo de energía no renovable (Mousaviavval et al., 2015). En el estudio del flujo de energía y los impactos ambientales, la producción en invernadero de plantas medicinales con un enfoque de evaluación del ciclo de vida, calefacción y estructura de invernadero representa más del 90% del consumo de energía. (Khanali y HosseinzadehBndbafha, 2017). Investigando los efectos ambientales de los sistemas de producción de trigo alimentados con agua en Irán utilizando la evaluación del ciclo de vida, los efectos más mínimos y menos ambientales en el sistema de producción de trigo de agua se obtuvieron respectivamente para los grupos de efecto de calentamiento global y eutrofización del sistema de riego (Khoramdel et al, 2014) mientras que en el sistema de producción de trigo alimentado por lluvia, los grupos de efectos se relacionaron con la eutrofización y la acidificación del agua. Estos investigadores calcularon el rango del índice ambiental de sistemas de producción de trigo alimentados con agua y lluvia, respec

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Assessing lifecycle, the most share of grain maize production system was obtained for acidification (2.59) and changing climate (0.61) (Khoramdel et al , 2012). Assessing sugar beet life cycle, water resources depletion damages environment more than other effects (Mirhaji et al, 2016). Assessing environmental effects of cereals production in Khorasan province using lifecycle assessment, these environmental effects also increase by increasing nitrogen (Fallahpour et al, 2012). Since understanding the complexities of environmental interactions in the production of foodstuff requires the use of new and effective methods, and LCA for food products is a new field in industrial production systems, and also given the importance of assessing the environmental status of sugarcane production systems and the fact that there are no published results related to this industry in the country, so this study evaluates the life cycle of sugar production in Khuzestan province. Considering that the country's total demand for sugar is 2.100.000 tons, of which 1.400.000 tons are produced in the country, and the Haft Tappeh agro-industry units in Khuzestan province provide 50 percent of this need,and the unit in this study is one of the seven units in Khuzestan province, and the data of 6 units of sugarcane productionare almost the same and there is a single policy in the management of sugar industry in Khuzestan province, the life cycle diagram is implemented and the results obtained from it have the ability to generalize and exploit in other units.In addition, it can show the total contribution of seven units in effect classes, and can also provide solutions to the environmental hazards of this vast project and reduce the environmental effects significantly at the damage points.

tivamente, como 0.47-0.55 y 0.34-0.43 por tonelada de grano.Al evaluar el ciclo de vida, la mayor parte del sistema de producción de maíz en grano se obtuvo para la acidificación (2.59) y el cambio climático (0.61) (Khoramdel et al, 2012). La evaluación del ciclo de vida de la remolacha azucarera, el agotamiento de los recursos hídricos daña el medio ambiente más que otros efectos (Mirhaji et al, 2016). Al evaluar los efectos ambientales de la producción de cereales en la provincia de Khorasan mediante la evaluación del ciclo de vida, estos efectos ambientales también aumentan al aumentar el nitrógeno (Fallahpour et al, 2012). Dado que la comprensión de las complejidades de las interacciones ambientales en la producción de alimentos requiere el uso de métodos nuevos y efectivos, el ACV para productos alimenticios es un campo nuevo en los sistemas de producción industrial y también la importancia de evaluar el estado ambiental de los sistemas de producción de caña de azúcar. el hecho de que no hay resultados publicados relacionados con esta industria en el país, por lo que este estudio evalúa el ciclo de vida de la producción de azúcar en la provincia de Juzestán. Considerando que la demanda total de azúcar del país es de 2.100.000 toneladas, de las cuales 1.400.000 toneladas se producen en el país, y las unidades de agroindustria Haft Tappeh en la provincia de Khuzestan brindan el 50 por ciento de esta necesidad, y la unidad en este estudio es una de las siete unidades en la provincia de Khuzestan, y los datos de 6 unidades de producción de caña de azúcar son casi los mismos y existe una política única en la gestión de la industria azucarera en la provincia de Juzestán, se implementa el diagrama del ciclo de vida y se obtienen los resultados tiene la capacidad de generalizar y explotar en otras unidades. Además, puede mostrar la contribución total de siete unidades en clases de efecto, y también puede proporcionar soluciones a los riesgos ambientales de

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. On this basis, the current study is sought to respond following questions.
- Which one of unit processes in sugar production does have significant environmental effects?
- What solutions are there to reduce environmental effects of sugar production in Khuzestan Province?

MATERIAL AND METHODS
Study Area

Amir kabir Cultivation and Industry Company is one of seven units of sugarcane cultivation unit, belonging to the Sugarcane development and Lateral Industries Company in Khuzestan. five units of them are located in the south of Ahvaz, one unit in its north and the other one is located in Shoeybiyeh area. out of 5 units in south of Ahvaz, 2 units are located in west coast of Karoon River and 3 units in its east coast. Amir Kabir Cultivation and Industry Company is one of dual units of Karoon River west coast in the road of Ahvaz to Khorramshahr.
The study area with the area of 15000 hectares is located 45km of southwest of Ahvaz-Khorramshahr Road. This area is in the divisions, approved by Ahvaz. It is restricted to the villages of Malihan and Takhtiye from north and old road of Ahvaz-Khorramshahr and national railway in the region from south. The mainland of area extends between 48°12' and 48°21' east longitude and 30°45' and 30°56' north latitude.
Sugarcane Farming Crop
Sugarcane (Saccharum officinarum) is perennialgrass of the family Poaceae, native to the warm temperate to tropical regions. In case of sufficient growth, this plant is two to six meters tall and its stem is relatively hard and fibrous, rich in sugar. In herbal hierarchy, sugarcane has the most outcome in

este vasto proyecto y reducir los efectos ambientales de manera significativa en los puntos de daño .

. Sobre esta base, se busca el presente estudio para responder las siguientes preguntas.
- ¿Cuál de los procesos unitarios en la producción de azúcar tiene efectos ambientales significativos?
- ¿Qué soluciones existen para reducir los efectos ambientales de la producción de azúcar en la provincia de Khuzestan?

photosynthesize process and it reaches to 2% in converting sun energy to organic material. Sugarcane is used to produce sugar in Iran. Yet, the crop is used for two purposes (sugar and forage production) in countries such as India, Pakistan, Mexico, Brazil and so on (Igbal, 2014). Sugarcane a perennial crop, having higher production yield compared to other forage plants.

Method
To conduct this research, five classes of environmental effects were investigated including eutrophication, acidification, global warming, photochemical oxidation and ozone layer depletion according to the ISO standard. The data about Amir Kabir sugarcane agro-industry unit, based on the average consumable inputs, were collected during the year 2015 by visiting the fields through questionnaires, interviews and then reviewing the documentation. All the organic and chemical inputs in the process of producing sugar from the sugarcane stem were obtained. The average consumption of inputs and output of the sugar production process is shown in Table 1. The data required in this study are cycleinputs that are harvested from the main sectors of agriculture and industry and related

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sub-sectors. Outputs to the environment were calculated based on emission factors. The life cycle effects were evaluated using CML 2000 and then the environmental effects were analyzed using the SIMAPRO 8 software.

Life Cycle Assessment

In accordance with the ISO 14040 instruction for implementing a life cycle assessment of a product or activity, there are four phases including the determination of the purpose and scope of the operation, taking the inventory and system boundary, the assessment of the life cycle effect and the interpretation of the results in an LCA study as follows:

a) Goal and Scope Definition

The aim of this study is to assess environmental effects of producing one ton of sugar from sugarcane plant in Amir Kabir Cultivation and Industries. The rate of releasing pollutants (in form of five groups of CL 2000 method) during cultivating sugar from sugarcane in the industry sector is estimated during the assessment and to reduce the environmental effects of producing one ton of sugar, some solutions will be proposed. In addition to the mentioned cases, identifying the opportunities in order to improve the environmental yield of sugar production in different points of lifecycle, informing the decision makers in industry, governmental and non-governmental organizations for strategic planning, prioritizing, designing or redesigning the product or processes, choosing related indexes to the environmental yield such as measuring techniques are of the other aims of this study. the aim of lifecycle assessment in this study is to study the implementation of inventory analysis and results interpretation. This study has been introduced through two methods that are studying the life cycle assessment and life cycle inventory in the standard of ISO 14044. Generally, the developed data in life cycle assessment or life cycle inventory study can be used as a part of comprehensive decision making process.

b) Inventory and System Boundary

In this research, the functional unit was considered as one ton of sugar. Functional unit is the quantization of the performance of a product system for its use as a reference unit, which means that the results presented in the performance measurement sector are defined for the functional unit and can be measured based on productionor service performance. In the present study, the scope of life cycle assessment of one ton of sugar was defined to clearly determine the function (performance characteristics) of the under study system. The functional unit in this study (ie, the production of a ton of sugar) is consistent with the purpose and scope of the study. Because the main purpose of the functional unit is to provide a reference in which the input and output data (in the mathematical sense) are normalized.

Due to the fact that sugar is produced in Agro-industry unit of Amir kabir in Khuzestan during cultivation and industrial processes, the LCA range includes all operations of industrial processes of producing one ton of sugar; which include the system boundary of sugar production study in the industrial sector. In this stage, the inputs, waste and pollutants by sugarcane production were determined and applied in terms of functional unit. Taking the inventory of the industrial sector includes all inputs and outputs that directly cover the process of producing one ton of sugar from the time sugarcane arrives to the factory until one ton of sugar is produced (Figure 1).

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Table 1- Inventory of Sugar Production life cycle

	Inputs/outputs	Unit	tone of raw sugar
Raw materials	Cane (sugarcane stem)	kg	74079.525
	Water	M·	22.648
Consumption materials	Caustic Soda	tone	0.001
	Sodium carbonate	tone	0.003
	Triple Superphosphate	kg	0.553
	Anti-adhesive	lit	0.072
	Limestone	tone	0.090
	Calcium hypochlorite	kg	0.466
	Dispersant	kg	0.025
	Antibacterial	kg	0.004
	Sulfur	kg	0.366
	Activated carbon	kg	0.227
	Aluminum sulfate	kg	1.487
	Coagulant aid	kg	4.400
	Citric acid	kg	0.015
	Hydrazine	kg	0.011
	Tri Sodium Phosphate	kg	0.269
Energy	Electricity	KWh	6.739
	Gasoline	lit	2.912
	Petrol/Fuel oil	lit	0
	Natural gas	M·	944.930
Product	White sugar	tone	--
	Raw sugar	tone	--
	Mud filter	tone	0.423
	Filter cake	tone	0.066
	Molasses	tone	0.453
	Bagasse	tone	3.052
	Compost	tone	0.809
Waste / wastewater	Industrial treatment plant sludge	M·	0.003
	Sanitary treatment plant sludge	M·	0.0008
	Industrial water treatment plant sludge	M·	0.294
	Industrial wastewater	M·	1.957
	Human sewage	M·	1.214
	Waste oil of producing lime	Lit	0.350
Emission to the water	COD	kg	19.1
	BOD	kg	.3
	TSS	kg	13.1
	PO·	kg	0.37
	O&G	kg	0.1
Emission to the air	TSP	kg	1.7
	SO,	kg	1.21
	NO,	kg	1.26
	VOC	kg	0.65
	CH,	kg	0.002
	N,O	kg	0.26

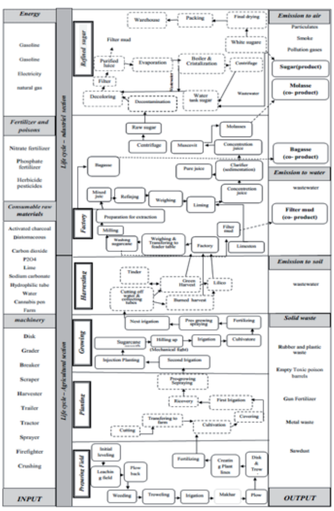

Figure 1- Life Cycle System Boundary

c) Life Cycle Assessment

In order to analyze the results quantitatively for each one of effects, special impact coefficient was defined. Life cycle effects assessment has been performed based on eco-Invent database 2.2. life cycle effects assessment in this study has been conducted using CML 2001 (Centre for Environmental Studies 2001). This is a middle class method of assessing life cycle, which is widely used. The effects of acidification, global warming potential, eutrophication potential, abiotic components depletion and the potential of depleting ozone layer that all exist in eco- Invent database. All environmental effects have been analyzed using Simapro 8.2 software.

d) Results Interpretation

In the last stage, the potential environmental effects of producing sugarcane are calculated and recommended solutions based on the obtained results.

RESULTS and DISCUSSION

After obtaining the data and completing inventory and then inserting them in SimaPro 8.2 software, the study results were obtained. Out of five proposed stages in ISO standard, only ranking and properties stages are considered in this study (ISO, 2006). In this section, the results of the study in each class are stated and each class will be also discussed as follows (table 2).

Table 2-. The potential effects Of Environmental Effect Class

(thtough Producing sugar from sugarcane)

Effect Class	Unit	amount
Reducing abiotic	kg Sbeq	0.000870173
Acidification	kg SO_2eq	21.94930135
Eutrificaiton	kg PO_4-eq	4.604542698
Global warming	kg CO_2eq	1701.765099
Ozone layer depletion	kg CFC-11 eq	0.000283694

Abiotic Resources Depletion

Abiotic resources depletion refers to the use of non-living resources such as fossil fuels or minerals, reducing the future generation accessibility to these resources. The rate of effect class of abiotic resources depletion for producing a tone of sugar was obtained as 0.00087 (fig. 2). Whole process of sugarcane production has the maximum effect in this class so that 96.9% is dedicated to agriculture operations. Despite Bagasse production in sugar production, -33.5% effect has been observed in this class. The negative effect in life cycle assessment means that produced lateral products during production, for other consumptions,

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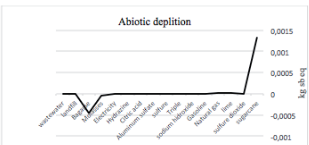
(such as using in electricity production or forage in agriculture) prevents consuming other materials (such as gas for electricity production in combined cycle power plants and forages for feeding the livestock), indicating negative effect of bagasse in this class of effect. Planting, cultivating and harvesting operations includes high rate of fuel consumption, due to undeveloped technology of agricultural tools in Iran, they consume more than optimal level. It has caused that sugarcane farming process have the most share whether in production or processing.



Global Warming Potential

In the section of producing sugar from sugarcane in processing company, the maximum global warming effect is dedicated to the input sugarcane into process to the rate of 1312.4kg as carbon dioxide. Since high rate of natural gas is used in the process, after input sugarcane, the maximum contribution of this effect class in processing section is related to natural gas burning to the rate of 309.4kg as carbon dioxide. The related emissions to the agriculture section in processing stage is 26% of whole effect class (fig. 3).

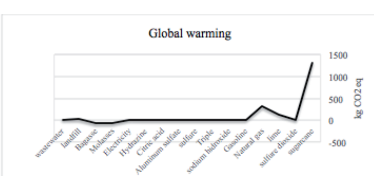


Figure 3- Global Warming class

In this effect class and producing sugar from sugarcane section, bagasse and molasses are considered as unavoidable products in production process and each one has the share of -76.9 and -79.7kg as carbon dioxide in reducing global warming in production process. This negative effect totally leads to less representation of global warming effects of producing sugar from sugarcane in industry. In a study by Farahani et al (2017) in Iran, subjected to economic functional unit in case of bioethanol production from sugarcane molasses, it was specified that electricity (52%) and using urea fertilizer (23%) have maximally affected global warming effect class in sugarcane production. Also, using 83% of natural gas in industry sector had the maximum effect on producing sugar from sugarcane (Farahani & Asoodar, 2017).

Eutrophication

Eutrophication is an unwanted increase in the production of biomass of land and water ecosystems due to the entry of nutrients such as phosphate and nitrate, which can change the composition of plant species.In Khuzestan, producing a ton of sugar in agriculture stage and paludification effect, 5.25kgPO4---eg equivalent to phosphate is released in the environment.In a research (Renouf et al., 2010), in sugarcane cultivation period, the amount of phosphate release was 4 kg equivalent to phosphate, which in present study was obtained 2.5%. in the agricultural sector. The difference in stated values is related to the method and process of harvesting, the type of machinery used and the method chosen for the study. Direct losses from the field and the production of triple super phosphate fertilizer with 63.6 kg of phosphate equivalent and release of sugarcanes with 0.95 kg of phosphate had the highest role in the effect class of peat formation, and other inputs didn’t have a significant effect on this effect class. In Figure 4, the participation rate of each of the inputs is shown on the peat formation effect class.

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In this effect class and in the section of producing sugar from sugarcane, bagasse and molassesare considered as unavoidable lateral products in production process and each one has the share of respectively -0.44 and -0.54kg PO4 in reducing eutrophication in production process. This negative effect totally leads to less representation of eutrophication effects of producing sugar from sugarcane in industry. (fig. 4)

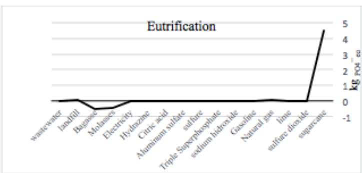

Figure 4- Eutrophication Class

Acidification Potential

In the process of producing sugar from sugarcane, the main factors of acidification in sugarcane agriculture have been the electricity and the sugarcane production process itself (including burning fossil fuels, burning straw and sugarcane and fertilizer).The obtained results of current study showed that for producing each ton of sugar in sugar production from sugarcane, 21.9kg SO2 releases in environment, having acidification effects. As shown in figure. 5 in this effect class and in the section of producing sugar from sugarcane, bagasse and molasses are considered as unavoidable lateral products in production process and each one has the share of respectively -1.12 and -0.6154kg SO4 in reducing eutrophication in production process. This negative effect totally leads to less representation of eutrophication effects of producing sugar from sugarcane in industry. (Fig.5)

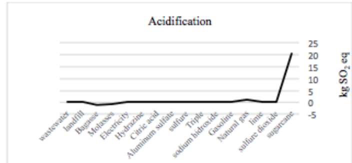

Figure 5- Acidification Class

Comparing the results of this study with other studies in the field of cultivating crops in Iran and abroad indicates that an adequate estimation of the emissions has been made. For example, in the study of strawberry production life cycle assessment, the acidification potential of production of a ton of strawberry was obtained 2.65 kg SO2 (khoshnevisan et al., 2013). In a research in Chile, using life cycle assessment, acidification per ton of rapeseed and sunflower oil was estimated 19 and 23 kg SO2 respectively (Iriarte et al., 2010). Reducing the use of fossil fuels and not burning straw and replacing organic fertilizers instead of chemical fertilizers can be a solution to reduce the acidification effects of the sugar production in agricultural sector. In the industrial sector, since the use of citric acid, natural gas and sugarcane itself as the main inputs, produce acidic effects that have played a major role, thus reducing the use of these materials or their replacement with non-acidic substances can the solution for the industry sector.

Ozone Layer Depletion Potential

Chlorofluorocarbons are of the most important materials, capable of ruining ozone layer (Guinee et al, 2001). Destructing ozone layer can be followed by the impacts such as skin cancer, the entrance of molecular damages to the materials, damaging plants and animals, occurring due to increase of passing ultraviolet ray (Bare et al, 2011).

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In Khuzestan, for producing a ton of sugar from sugarcane, 28mg in the section of processing CFC-11 pollutants releases into environment, destroying ozone layer in stratosphere. The results of current study showed that diesel fuel in the processing of sugar from sugarcane has the maximum share in producing CFC-11 pollutants. Producing chemical fertilizers, electricity and pesticides totally affected depletion of ozone layer. Figure 6 shows the effect of each input on ozone layer destruction. The results of this study are similar to those of other studies in this field. For example, in assessing the strawberry life cycle in Gilan, it was found that diesel fuel production has the greatest impact on the depletion of the ozone layer (khoshnevisan et al., 2013). It was also shown in Chilean rapeseed and sunflower oil life cycle assessment that the production of diesel fuel and fertilizers had the most important effect of the ozone layer depletion (Iriarte et al., 2010).

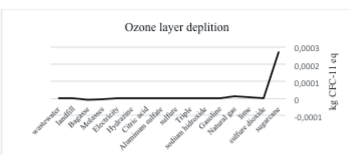

Figure 6- Ozone layer depletion class

CONCLUSION

It can be concluded in the case of environmental emissions that the decision and policy makers need to concentrate on solving the problems associated with global warming, toxicity for humans and ozone layer depletion from cultivation to chemical processes. Traditional sugarcane industry faces a lot of problems about wastes because these wastes contain chemical materials, used during liming, sulfating and phosphating to process raw syrup and eliminate the color. In sugarcane industry, traditional methods are used in eliminating the material such as anti-adhesives, anti-bacteria etc. accordingly, a super-refining process is required to have a pure syrup with the least color. Polyether sulfone filters (5-100 kDa MWCO) (PES) and Carbosp filters (15-50 kDa MWCO) are used to reduce the color for refining the syrup well. On this basis, refining process significantly reduces related problems to the pollution associated with sugarcane industry (Karoda et al, 2000). Because these materials don't have main roles in lifecycle process in defined effect classes and also in defined field for wastes disposal, the presumption of the current study is principled disposal of filters through waste disposal. Since waste disposal isn't studied here (it is not included in lifecycle whole assessment and doesn't consider finishing point of lifecycle) and the study is assessing a middle process, so waste disposals of these filters aren't included in lifecycle assessment.

Few industrial processes provide a unit output or are based on linearity of inputs and outputs of raw material. In fact, most of industrial processes produce more than one product and recycle middle or disposed products as raw material. Allocation is an important part in lifecycle assessment. In sugar industry, due to the outputs such as sugar, bagasse and molasses, allocation is undeniably crucial. Yet, allocating bagasse in lifecycle assessment studies isn't considered because it is used for producing steam and electricity. However, bagasse and molassesare considered as unavoidable lateral products in the current study and their environmental effects have been considered in all classes. Although profound depletion

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of negative effects of producing sugarcane isn't practically possible but its range and intensity can be usually decreased to the great extent. Such as measure includes elimination, reduction or controlling undesired environmental effects of projects, including compensating damages of environmental consequences through displacement, renewal, resuscitation by following methods.

Using citric acid, natural gas and sugarcane as the main input leads to acid effects, having the maximum share. Reducing the use of these materials or replacing them with those, lack acidity, can be a solution in reducing acidity effects in producing sugar. The most effect of eutrophication is related to agriculture, can be reduced significantly through agriculture considerations as well as using lateral products and refining the wastewaters of factory. High rate of global warming potential in sugar production is majorly because of high use of natural gas. Producing steam and electricity energy during whole process of sugar production can reduce the use of natural gas and increase the efficiency of energy consumption and reduce global warming effects for functional unit. The emissions, arising from producing chemical fertilizers, producing and burning fossil fuels, have significantly affected ozone layer depletion in whole process of producing sugarcane (from planting sugarcane to producing sugar). Correcting industrial processes, in which fossil fuels use is high, reduces the effect of ozone layer depletion in sugar production process. Abiotic resources depletion was also studied in the current paper and it was specified that for producing a ton of sugar in agriculture and industry section, the effects are related to pesticides and fossil fuels. Since the in the section of producing sugar from sugarcane, whole process of producing sugarcane has the maximum effect in this class, so that 96.9% is dedicated to agricultural operations, the recommended solution for whole related process relate

to agriculture section and it is reducing pesticides and fossil fuels and replacing them with biologic methods such as biologic control of pests instead of merely use of pesticides in the process of producing sugarcane.

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