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EVALUATING AND COMPARING THE POTENTIAL ENVIRONMENTAL IMPACTS FROM THE PRODUCTION OF DIESL AND LIQUEFIED PETROLEUM GAS, AL-DAURA REFINERY, BAGHDAD, IRAQ

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Abstract: Petroleum is the main source of energy in the world, plays an important role in human life, but also its have many environmental impacts. Various software's are designed to focus on the environmental impacts of Petroleum production and accomplish the assessment, one of these software's is SimaPro software package which is designed to make a valuable contribution. It is an essential tool for analyzing the environmental impact of products during their whole life cycle. A huge amount of knowledge about the environment is built into the program and database, enabling to analyze a product with a minimum of specialized knowledge. In this study, SimaPro7 is used to analyze and evaluate the impacts for AL-Daura refinery for the Diesel and LPG (liquefied petroleum gas) fuel production .The results of LCA are not mostly straightforward in favor of material design over the alternative one. The IMPACT2002+ methodology is used for evaluating the products. This method has proved to be a powerful tool for designers to aggregate LCA results in easily and understandable form. The results of Life Cycle Assessment (LCA) show that Diesel has an impact and damage on the environment (single score) of the order of 0.300302 point for each 1 cubic meter producing from Diesel fuel while LPG has a single score of 0.191243, (The "Single Score" variable is measured in units of points (Pt), which indicates the potential number of people affected by the environmental impacts taken into consideration a period of one year).

Key words: *Diesel, LPG, AL-Daura refinery, Refining, Baghdad, Simapro7, Life cycle assessment.*

تقييم ومقارنة التأثيرات البيئية المحتملة من انتاج الديزل والغاز المسال ، مصفى الدورة ،بغداد، العراق

الخلاصة: البترول هو مصدر الطاقة الاساسي في العالم حيث يلعب دور مهم جدا في حياة الانسان ،لكنه كذلك يمتلك العديد من الاثار البيئية .العديد من البرامج صممت لتسليط الضوء على انتاج البترول والقيام بعملية تقييم اثاره. احد هذه البرامج هو SIMAPRO7 لعمل تقييم ذوى مغزى والذي يعتبر كأداة مهمة لتحليل الاثار البيئية لاي منتج خلال دورة حياته . العديد من المعلومات عن الاثار البيئية تم انشائها داخل قاعدة بيانات البرنامج ، حيث يمكن من خلالها تحليل الاثار البيئية للمنتج باقل معلومات متوفرة .هذه الدراسة استخدمت برنامج SIMAPRO7 لتحليل وتقييم الاثار البيئية الناتجة من عملية انتاج الديزل والغاز السائل من مصفى الدورة كحالة دراسة ،وكانت الطريقة المستخدمة لتحليل المنتج هي IMPACT2002+ .هذه الطريقة تم وضعها لتكون وسيلة قوية للمصممين لتجميع نتائج منهج دورة الحياة LCA بطريقة سهلة ومفهومة .نتائج تقييم دورة الحياة اظهرت بان الديزل الاثار الناتجة من انتاج الديزل هي (0.300302) نقطة لكل متر مكعب من الديزل مقارنة بتلك الاثار الناتجة من الغاز السائل والتي تقدر ب (0.1912) .مؤشر Single Score يمثل بالنقاط والتي تعبر عن عدد الاشخاص الممكن تاثرهم بالاثار البيئية لعملية ما خلال فترة زمنيه مقدارها سنة واحدة .

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1. Introduction

Currently there is a conflict between the nature limits and the aspirations of human beings in this world, {1}.

Despite the fact that petroleum product makes life less difficult, its life cycle from exploration to final use includes harm to the nature through air, water, and soil pollution, {2}.

The earth natural system is gradually altered by the anthropogenic pollution where the results and impacts can have adversative effects.

The discharge of CO_2 and other type of contaminants can generate difficult troublesome for society, the most notably problem is climate change, {1}.

Oil refinery or petroleum refinery is an industrial procedure where unrefined petroleum is treated and refined into further valuable products e.g. naphtha, gasoline , diesel, asphalt, heating oil, lamp fuel and liquefied petroleum gas, {4}, more details are shown in fig. 1. Petroleum refineries are commonly substantial, extensive, modern structures with broad funneling running all through, conveying surges of fluids between vast concoctions preparing units .

There are a few procedures required in handling unrefined inputs to make them useable and attractive fuel yields, {5}.

Life Cycle Assessment (LCA) is a standard international tool, ISO 14040, used to evaluate the environmental impact of products, processes and services.

It considers as the entire life cycle, from raw material extraction, to manufacture, distribution, use, end of life treatment, recycling and eventually disposal {6}.

SimaPro 7 software is used for database on resources consumption and environmental emissions in the present LCA {7}.

The aim of this study is evaluating the environmental impacts of the diesel and LPG fuel production.

2. Study Area

Baghdad, the capital of Iraq, is located at the middle of Iraq (Fig. 1). AL-Daura Refinery is located in AL-Daura region, southeast of the capital Baghdad.

AL-Daura Refinery characterized by its important location on the banks of Tigris River, covers an area of (808) acres and (47) meter about (205 Hectares) bounded from the north and west by Tigris River, from the east by the high way, and from the south by the houses of the Refinery staff.

Producing capacity is currently about (210 thousand barrels per a day).

Figure 1 AL-Daura refinery

2. Methodology

The necessary data have been collected from reports of the environmental and production units of AL-Daura refinery for 2015 year, as shown in table 1 . SimaPro 7 software (System for Integrated natural Assessment of Products), created by the Dutch PRé Consultants (PRé, 2005), has utilized as a life cycle assessment LCA modelling and analysis tool, {8}.

This serves as a tool for managing and storing data, making calculations and sensitivity tests. The LCA phases are structured in SimaPro in accordance with ISO14040 and ISO14044 LCA standards {9}.

2.1. *Goal and Scope Definition in SimaPro*

A special section is available for a description of the goal and scope for each project. There are three sections and these include:

- Text fields into which a description of the different aspects of the goal and scope definition can be made. Text entered here can be later copied and pasted into the report [6]. The goals of this research are to analyze and to evaluate the environmental impacts of diesel and LPG production.
- Libraries section in which it is possible to predefine which libraries with standard data are considered relevant for the project to be run [6]. In this research, the library of ecoinvent system processes was selected.
- Data quality section where data characteristics can be predefined [6].

2.2. *Inventory Analysis*

The inventory analysis involves parameters describing resources uses, material uses and emission to air and water. The assessment covers throughout the entire life cycle of the products or activities; construction; treating; sludge disposal; and all transportation involved.

An important goal of data collection is to establish a database which can be used on an ongoing basis for LCA.

The data for a process must be collected in form, so called normalizing the process.

2.3. *Impact Assessment*

In SimaPro There are a wide variety of impact assessment methods available in SimaPro. The basic structure of impact assessment methods in SimaPro is characterization, damage assessment, normalization and weighting.

The last three steps are optional according to the ISO standards [9].

In this study, the IMPACT2002+ method was used to determine the environmental impacts of the diesel and LPG.

2.4. *Interpretations*

This is designed as a checklist which covers the relevant issues mentioned in the ISO standards used. As suggested by PRé Consultants (2010), observations are filled in when the LCA study is about to be completed and conclusions are made [6].

Table 1: Inventory analysis of Diesel and LPG fuel.

products / Inventory	LPG	Diesel
✓ Resource use:		
Water	0.8128 kg	1.27465 kg
Crude oil	554 kg	870 kg
✓ Materials		
DMDS	0.0000090689Kg	0.00001422kg
PDC	0.00047485 Kg	0.00074463 kg
Sodium hydroxide	0.000005351 kg	0.000008391Kg
Fuel Oil	1.70931 Kg	2.68042 Kg
Fuel Gas	2.759557 kg	4.32737 kg
✓ Energy uses		
Electricity	11.29103 KWh	18.69383 KWh
Steam	337.8303 kg	529.765 kg
✓ Emission to air	0.100977 kg	0.158345 kg
Carbon dioxide	0.0061047kg	0.00098582kg
Nitrogen oxide	0.002238 kg	0.0035098 kg
Sulfur dioxide	0.0565 kg	0.0886696 kg
Water		

Table 1: Continue

products / Inventory	LPG	Diesel
✓ Emission to water	0.00036002 kg	0.00056667 kg
BOD	0.0018231 kg	0.0028570 kg
COD	0.01650 kg	0.025875 kg
SO4	0.02274 kg	0.03566 kg
CL	0.0000037325 kg	0.000005860 kg
PO4	0.0004646 kg	0.000072969 kg
OIL	0.053134 kg	0.083319 kg
TDS	0.0000084436 kg	0.00000132428 kg
S	0.00112335 kg	0.0017589 kg
ss	0.000001114kg	0.000017404kg
Phenol	0.0003696 kg	0.00005739 kg
Zn		
✓ Sludge	$1.12726*10^{-3}$	1.76770*10-3

Based on reports from environmental and production units in AL-Daura refinery*

4. Results and Discussion

Input consists of resources –water and crude oil for refining process, material (water, fuel oil and gas oil) for steam and electricity generation, (PDC, DMDS, and Sodium hydroxide) for production purpose.

Emission of refining process can be classified into two main groups; emission to air – CO_X, SO_X , H_2O and NO_X which come from refining process especially from the electricity and steam generation process. Emissions to water include– BOD, COD, SO4, CL, OIL, TDS, S, SS, and Phenol, which have wastewater (industrial wastewater) characteristics.

The Impact 2002+ method is known as a midpoint/damage approach to LCA as shown in fig2. A user defined description of the raw materials, emissions, and energy uses associated with a particular process is entered into Simapro7, Impact 2002+ then quantifies the impacts of these steps in terms of fourteen environmental impact categories, the fourteen categories are also grouped into four damage categories, including human health, ecosystem quality, climate change, and resources which are finally normalized to one value single score, these steps are shown in figure 3.

The fourteen environmental impact or midpoint categories in the IMPACT2002+ method are human toxicity (carcinogens and non-carcinogens), respiratory effects, ionizing radiation, ozone layer depletion, photochemical oxidation, aquatic ecotoxicity, terrestrial ecotoxicity, terrestrial acidification/nitrification, aquatic acidification, aquatic eutrophication, land occupation, global warming, non-renewable energy and mineral extraction. While the damage categories are human health, ecosystem quality, climate change and resources.

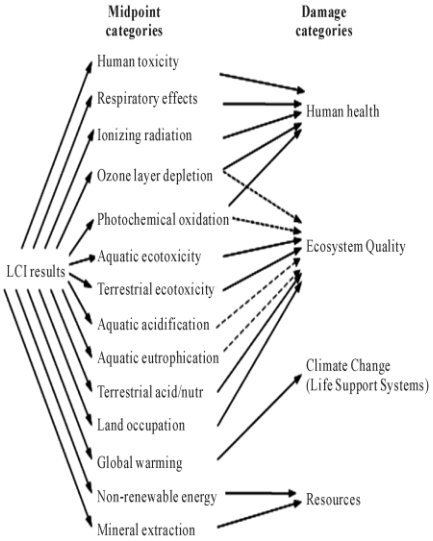

Fig. 2: Overall scheme of the Impact 2002+ Framework, Linking LCI results via the midpoint categories to damage categories. Based on Jolliet Et Al. (2003a) {PRé Consultants, 2007}.

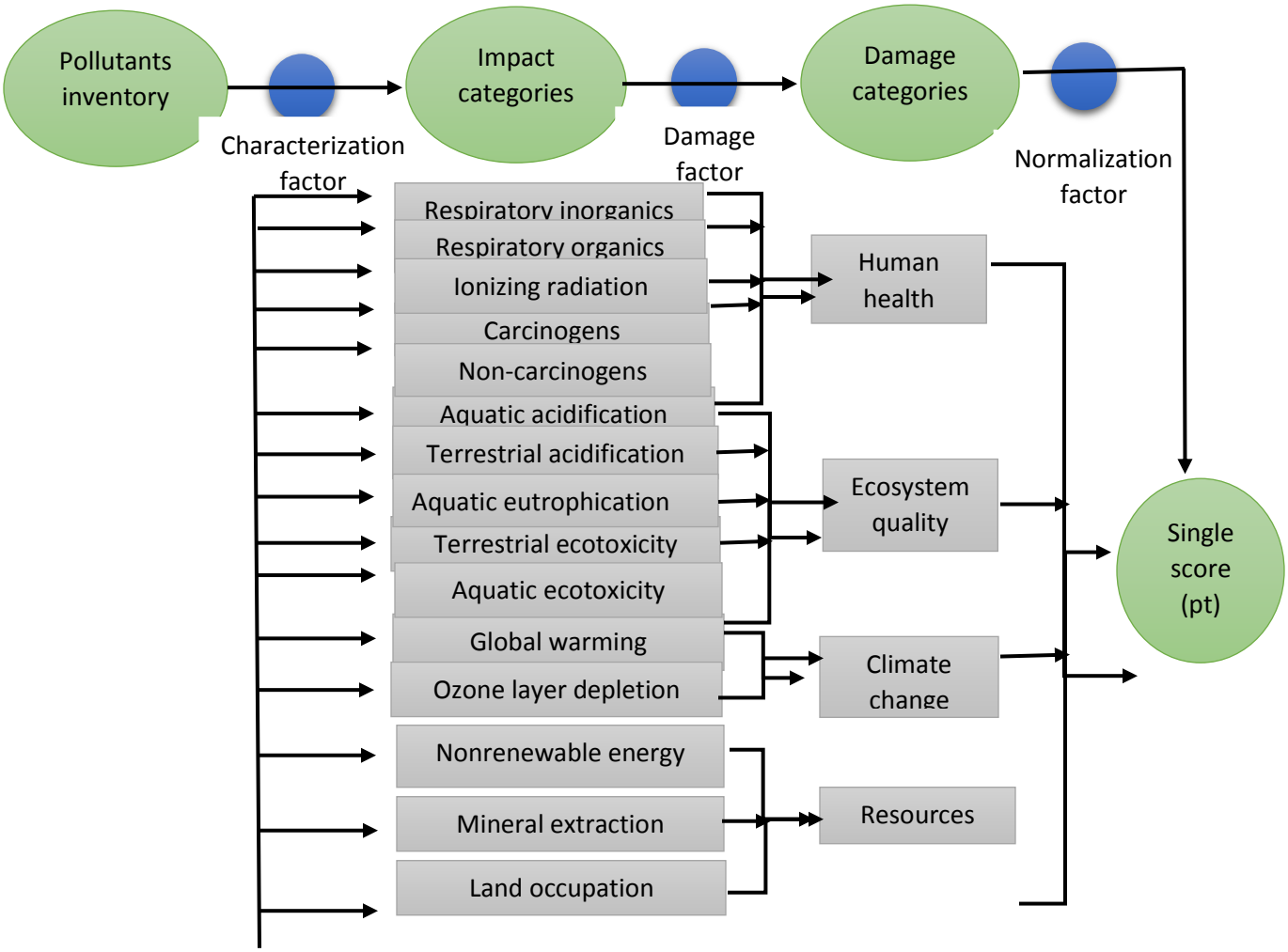

Fig. 3: Steps for environmental impact assessment according to Impact 2002+ Method {researcher}

4.1. *The Single-Score in Terms of Impact Categories (Midpoints) Of AL-Daura Refinery*

The single-score in terms of impact categories of AL-Daura refinery is shown in Fig. 5.

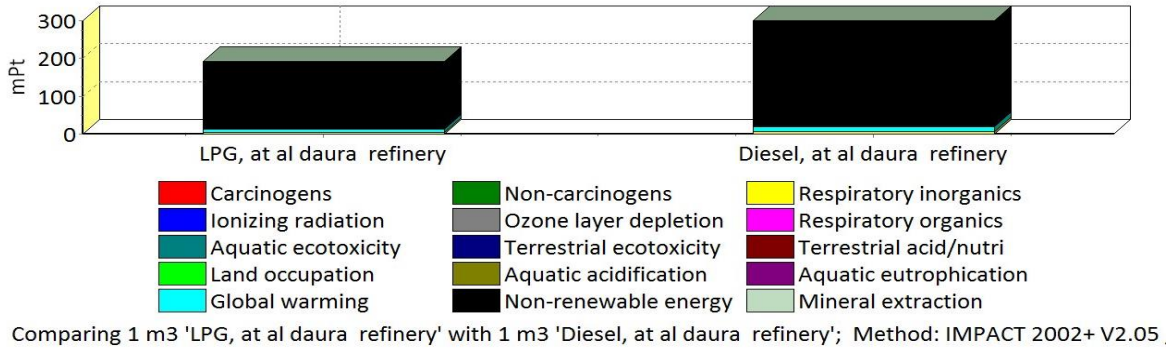

Fig. 4: Single score in terms of impact categories of Al-Daura refinery.

These result show that the most environmental impacts potential are resulting from non-renewable energy, respiratory inorganic and global warming, contributing to the two products. Also these three most effective impact categories for diesel was much greater than that for LPG. As shown in fig 4, diesel impact is higher than LPG, the total single score of diesel is equal to 0.300302 Pt /m^3 of diesel compare to LPG of 0.191243 Pt /m^3 of LPG. Table 2 shows these categories in details.

Table 2: Single score in term of impact categories of AL-Daura refinery.

Impact category	Unit	LPG, at Al-Daura refinery	Diesel, at Al-Daura refinery
Total	Pt	0.191243	0.300302
Carcinogens	Pt	0.000291	0.000457
Non-carcinogens	Pt	7.04E-05	0.000111
Respiratory inorganics	Pt	0.003621	0.005609
Ionizing radiation	Pt	4.93E-06	7.77E-06
Ozone layer depletion	Pt	2.05E-06	3.23E-06
Respiratory organics	Pt	6.16E-06	9.7E-06
Aquatic ecotoxicity	Pt	1.68E-05	2.37E-05
Terrestrial ecotoxicity	Pt	0.000348	0.000549
Terrestrial acid/nutri	Pt	5.12E-05	7.73E-05
Land occupation	Pt	4.48E-06	7.06E-06
Global warming	Pt	0.008519	0.013409
Non-renewable energy	Pt	0.178306	0.280038
Mineral extraction	Pt	5.06E-07	7.96E-07

4.2. *Single Score in Term of Damage Categories of AL-Daura Refinery*

The damage categories are also analyzed by IMPACT 2002+. Four-categories of damage were pointed out: Human health, Ecosystem quality, Climate change and Resources, more details are shown in table 3. Also fig. 5 shows the single score in term of damage categories of AL-Daura refinery.

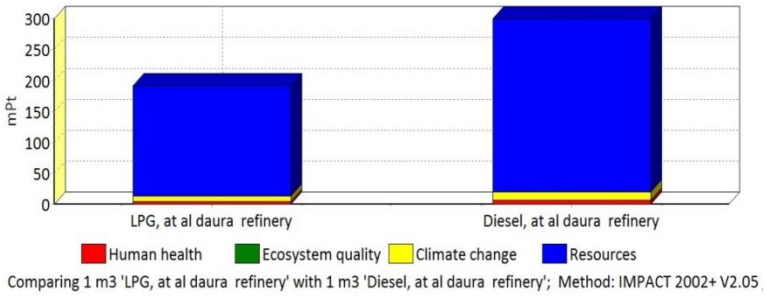

Fig. 5: Single score in terms of damage categories.

From Figure 5, it can be shown that the environmental damage on Human Health, Resources and Climate change are much more important than the damage on Ecosystem Quality. The damage from the diesel production for the four illustrated categories are greater than that of LPG. Diesel total damage was equal to (0.30030237 Pt), compare to LPG (0.1912429 Pt), the total refining damage categories are shown in table 3 I detailed.

Table 3: Single score in term of damage categories.

Damage category	Unit	LPG, at Al-Daura refinery	Diesel, at Al-Daura refinery
Total	Pt	0.1912429	0.30030237
Human health	Pt	0.003996239	0.006197907
Ecosystem quality	Pt	0.000420575	0.000656885
Climate change	Pt	0.008519482	0.013409261
Resources	Pt	0.17830661	0.28003832

4.3. *Contribution Analysis*

Contribution analysis is a significant tool which used to understand the uncertainty of results. This analysis helps in determining the process of significant role at result. Frequently the LCA can be verificated by hundreds different process, but indeed 95-99% of results are related to just ten processes, so when using contribution analysis we can focus our attention on these processes. The contribution analysis ways in SimaPro are as follow:

1. Contribution analysis section of the result screen as shown in table 4.
2. Graphical representation of the process tree or network: the relative contribution of each process can be evaluated by using the tree procedure. This methodology have benefit represented in getting the exact role of the process in the life cycle. See figures 6 and 7.

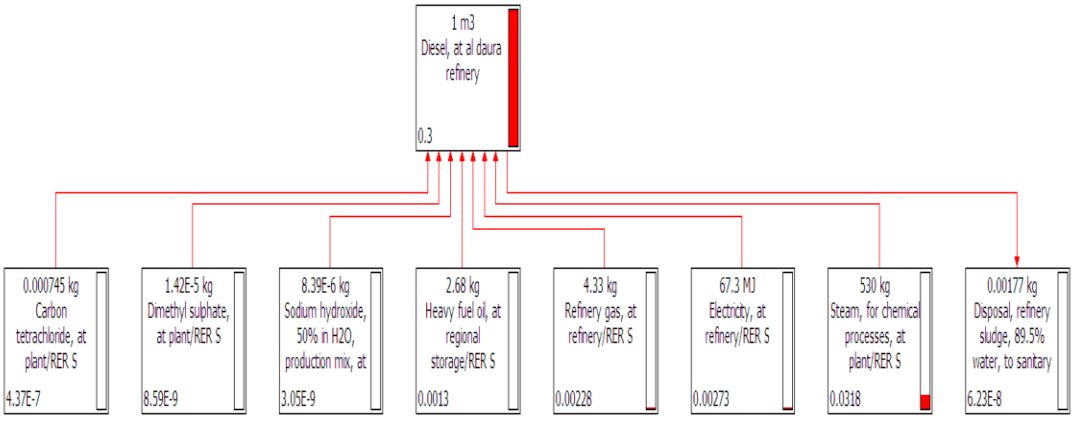

Fig. 6: Process contribution of Diesel

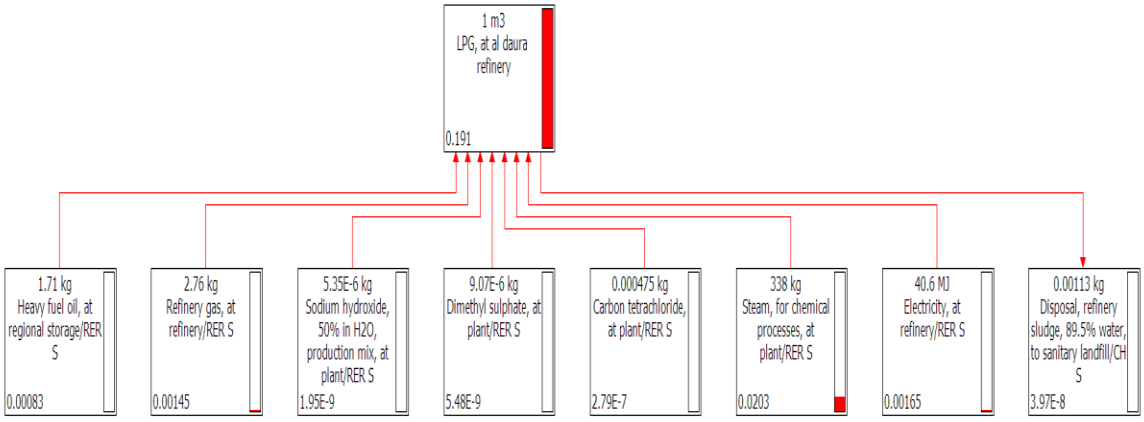

Fig. 7: Process contribution of LPG.

From the figure 6 and 7 and table 4 it shown that the impact and damage of the two products are mostly result from the process illustrated in the table rather than the other process.

Table 4: Process Contribution

Process	Unit	LPG, at Al-Daura refinery	Diesel, at Al-Daura refinery
Total of all processes	Pt	0.1912429	0.30030237
Refinery gas, at refinery	Pt	0.001451	0.002276
Steam, for chemical processes, at plant	Pt	0.02025	0.031755
Electricity, at refinery	Pt	0.001646	0.002726
Heavy fuel oil, at regional storage	Pt	0.00083	0.001302
Carbon tetrachloride, at plant	Pt	2.79E-07	4.37E-07
Disposal, refinery sludge, 89.5% water, to sanitary landfill	Pt	3.97E-08	6.23E-08
Dimethyl sulphate, at plant	Pt	5.48E-09	8.59E-09
Sodium hydroxide, 50% in H_2O, production mix, at plant	Pt	1.95E-09	3.05E-09
Diesel, at al daura refinery	Pt	-	0.262243
LPG, at al daura refinery	Pt	0.167064	-

5. Conclusions

The IMPACT2002+ is one of methods in SimaPro7.1.8, it is applied to evaluate environmental indicators for diesel and LPG production in AL-Daura refinery. The results indicates that single-score of diesel production is 0.3 Pt comparing with 0.191 Pt for LPG. The most environmental potential impacts are global warming, respiratory in organics and non-renewable energy, and these listed impacts for diesel was greater than that of LPG. Also the most notable damage categories were human health, Resources and Climate change.

Abbreviations

BOD	Biological oxygen demand
COD	Chemical oxygen demand
DMDS	Dimethyl disulfide
SS	Suspended Solids
TDS	Total Dissolved Solids
LPG	Liquefied Petroleum Gas

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