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Comparison of Potential Environmental Impacts on the Production of Gasoline and Kerosene, Al-Daura Refinery, Baghdad, Iraq

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Abstract

Oil represents the main energy sources used by mankind. In addition, petroleum products serve as feedstock for several consumer goods, thus playing an important growing role in people's lives. For this reason there are various software applications designed to do the environmental assessment to see their impact on the environment. Among these is SimaPro software package designed to make a valuable contribution. It is a powerful tool for analyzing the environmental impact of products during their whole life cycle. In this study, it was applied to analyze and evaluate the impacts for Al-Daura refinery for the gasoline and kerosene fuel production. This refinery located in Baghdad, Iraq was analyzed. The results of the life cycle assessment (LCA) show that gasoline has a (single score) of the order of 11.1 point for each 1 cubic meter produce from gasoline fuel compared with 4.83 point for each 1 cubic meter produce from kerosene. Global warming, respiratory inorganics and non-renewable energy were the most effective environmental impacts.

Keywords

Gasoline, Kerosene, Al-Daura Refinery, Refining, Baghdad, Simapro7, Life Cycle Assessment (LCA)

1. Introduction

Currently there is a conflict between the nature limits and the aspirations of human beings in this world [1]. Oil has numerous advantages and vitality and is fundamental for all activates related to human life; however for each phase in its life cycle it has dangers for the environmental systems, humans and wildlife [2].

The petroleum industry is considered as a main potential for risks on the ecosystem, and the impact is distributed on different levels: water, soil, air, and as a result all living beings on our earth [3]. The earth's natural system is gradually altered by the anthropogenic pollution where the results and impacts can have severe effects. The discharge of CO_2 and other types of contaminants can generate difficult problems for the society; the most notably problem is climate change [1].

Pollution is accompanied with practically all actions throughout all phases of petrol production, from exploration actions to refining. Large amounts of aerosols, gas emissions, solid waste and wastewater are generated during the petroleum fuel production chain (drilling, production, refining and transporting) [3].

The process where unrefined petrol is treated and refined into further valuable products e.g. naphtha, gasoline, diesel, asphalt, heating oil, lamp fuel and liquefied petrol gas is referred to as oil refining or petrol refining [4] (**Figure 1**). Petrol 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]. To evaluate the environmental impact of products, processes, and services, an international standard tool can be used. Life Cycle Assessment (LCA) is one of these tools, with ISO 14040. In this tool the entire life cycle is considered from raw material extraction, to manufacture, distribution, use, end of life treatment, recycling and eventually, disposal [6] [7]. In the present LCA, SimaPro 7 software was used for the inventory and database on resources consumption and environmental emissions [8]. The aim of this study is to evaluate the environmental impacts of the gasoline and kerosene fuel production. In this case Al-Daura refinery in Baghdad city, Iraq was considered.

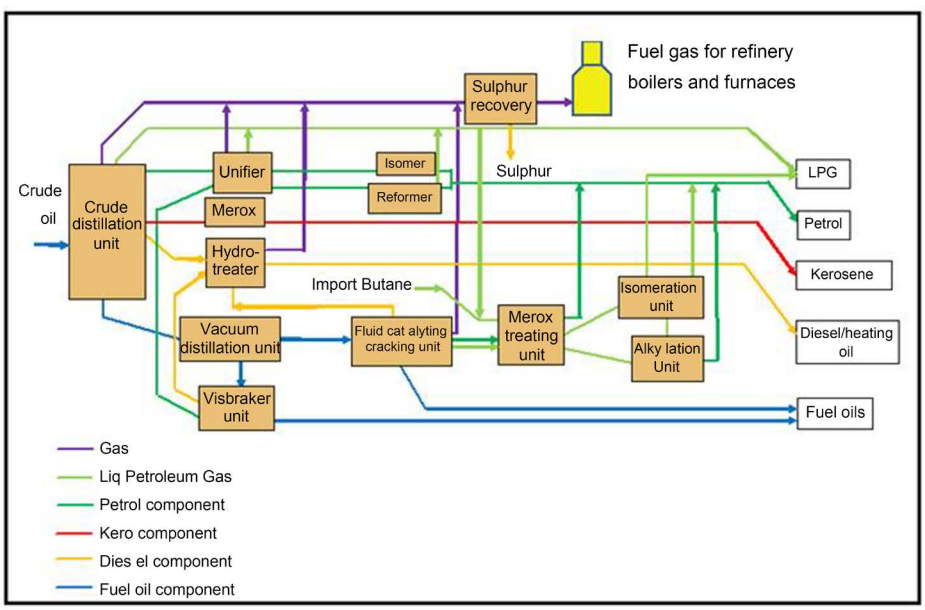

Figure 1. Typical petroleum refinery configuration [1].

2. Study Area

Baghdad is located on the River Tigris in the middle parts of Iraq and it is the capital of Iraq (Figure 2). Al-Daura Refinery) is located in Al-Daura region southeast of the capital Baghdad. It is characterized by its distinguished location on the bank of Tigris River. It 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 highway, and from the south by the houses of the Refinery staff. Producing capacity is currently about 210 thousand barrels per a day.

3. Methodology

The program SimaPro 7 (System for Integrated natural Assessment of Products), created by the Dutch PRé Consultants [6] [7], will be utilized as a life cycle assessment LCA modeling and analysis tool [9]. It manages and stores data, making calculations and sensitivity tests. In accordance with ISO14040 and ISO14044 LCA standards, LCA phases are structured in this software [10]. The main sections in the software are as follow:

1) Goal and Scope: In this section is the goal and scope are described. This can be done through:

- Different aspects of the goal and scope definition are done in this Text fields. This can be later copied and included into the report [6]. In this research gasoline and kerosene production are to be analyze and to evaluate their environmental impacts.
- Libraries with standard data which are relevant for the project can be picked in this section [6] [7]. The library of ecoinvent system processes was used in this study.
- Data characteristics can be predefined in this software [6] [7].

Figure 2. Location of the study area.

2) Parameters describing resources and material uses and emission to air and water is refered to ad "Inventory Analysis". This covers the whole life cycle of the products or activities; construction; treating; sludge disposal; and all transportation involved. In the LCA a so called normalization process is used for data collection to establish a suitable data base.

3) The basic structure of impact assessment methods in this software is characterization, damage assessment, normalization and weighting and the last three steps are optional according to the ISO standards [10]. For the gasoline and kerosene environmental impacts IMPACT 2002+ method was used.

4) For interpretations, a checklist which covers the relevant issues mentioned in the ISO standards is usually used. Observations are filled in when the LCA study is in its final stages and conclusions are made [6] [7].

4. Results and Discussion

The results were mostly not straightforward in favor of material design over the alternative one in LCA they got to be interpreted or weighted. For product design, IMPACT 2002+ methodology and LCA weighting method are used. It had proved to be a powerful tool for designers to aggregate LCA results into easily understandable and user-friendly numbers or units. This is called IMPACT 2002-IMPact Assessment of Chemical Toxics. The processes contributing to those impacts are detailed in **Table 3**.

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-BOD, COD, SO4, CL, OIL, TDS, S, SS, and Phenol. Those were wastewater (industrial wastewater) characteristics (see **Figure 3** and **Figure 4**). For analysis the Impact 2002+ method is used which known as a midpoint/damage approach to LCA. 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. These were also grouped into four damage categories (human health, ecosystem quality, climate change, and resources).

The fourteen environmental impact or midpoint categories in the IMPACT 2002+ 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. **Figure 5** shows linking LCI results via the midpoint categories to damage categories.

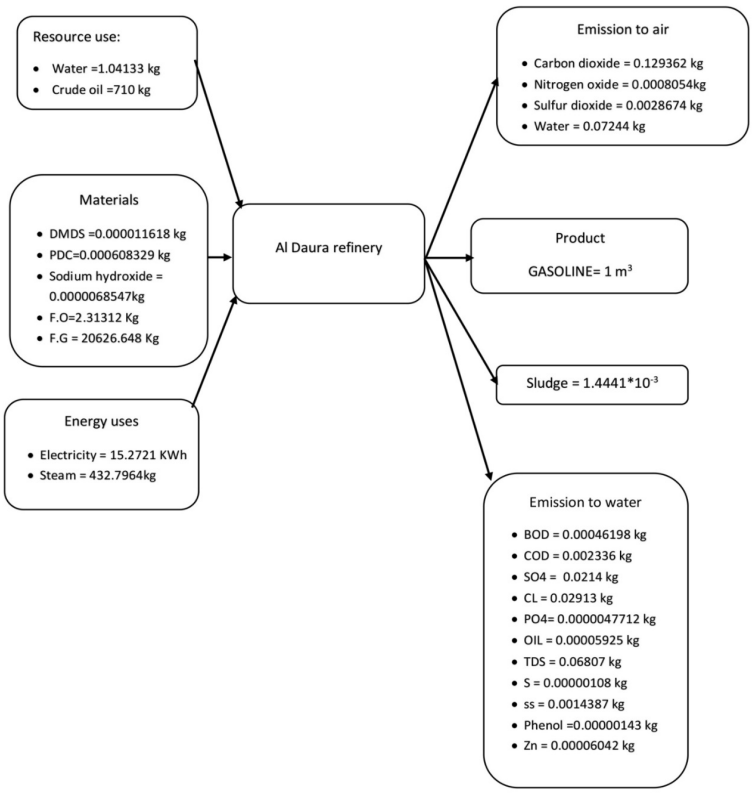

Figure 3. Inventory analysis of gasoline.

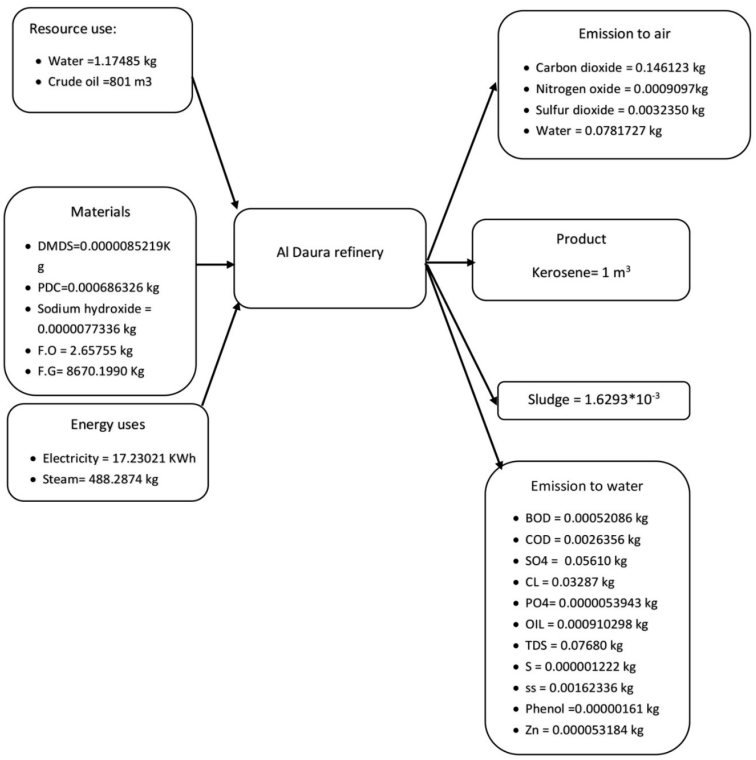

Figure 4. Inventory analysis of kerosene.

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

Figure 6 shows the single-score in terms of impact categories of Al-Daura refinery. Non-renewable energy, respiratory inorganic and global warming, contributing to the two products were the most environmentally potential. As shown in Figure 6 and Table 1, gasoline impact was higher than kerosene, the total single score of gasoline was equal to 11.1 Pt/m^3 of gasoline compare to kerosene of 4.83 Pt/m^3 of kerosene.

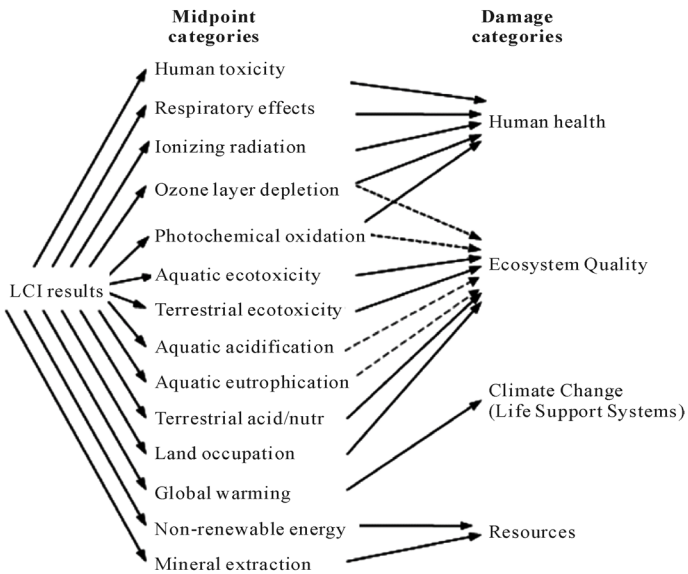

Figure 5. Overall scheme of the impact 2002+ framework, linking LCI results via the midpoint categories to damage categories. Based on [6] [7].

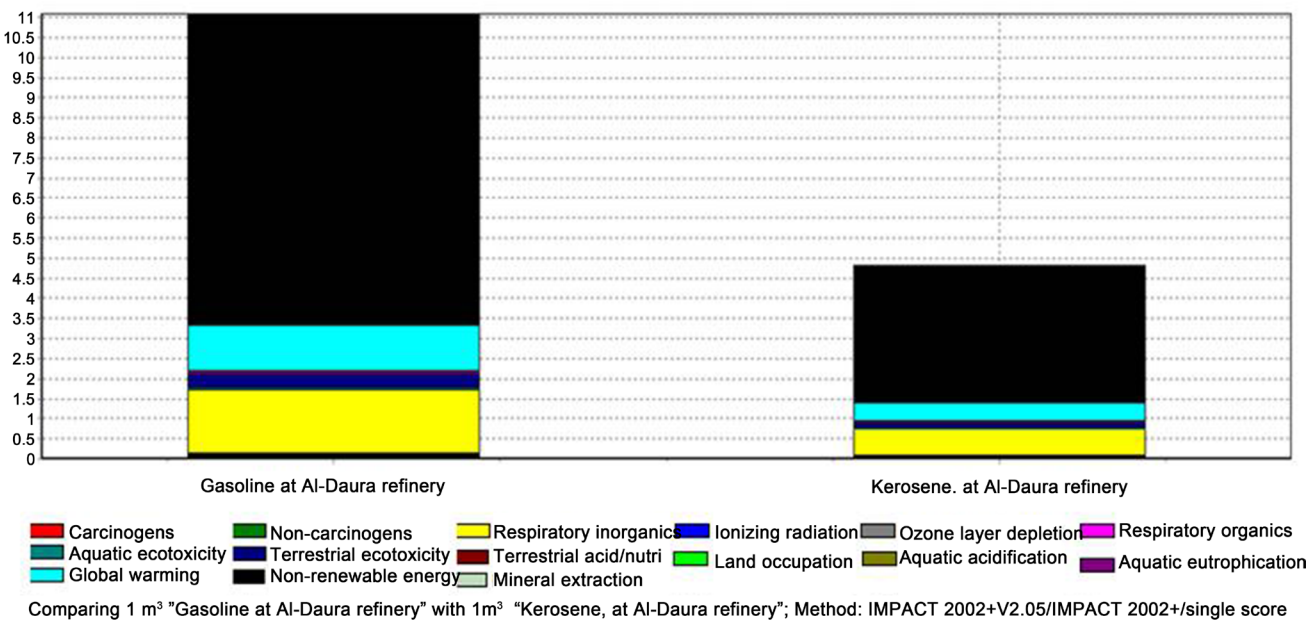

Figure 6. Single score in terms of impact categories of Al-Daura refinery.

Table 1. Single score in term of impact categories of Al-Daura refinery.

Impact category	Unit	Gasoline Al-Daura refinery	Kerosene, at Al-Daura refinery
Total	Pt	11.09088	4.834182
Aquatic acidification	Pt	-	-
Aquatic eutrophication	Pt	-	-
Mineral extraction	Pt	0.00033	0.000139
Ozone layer depletion	Pt	0.001444	0.000609
Ionizing radiation	Pt	0.004183	0.001762
Respiratory organics	Pt	0.005267	0.002219
Land occupation	Pt	0.005373	0.002262
Aquatic ecotoxicity	Pt	0.010761	0.004536
Terrestrial acid/nutri	Pt	0.023441	0.009895
Carcinogens	Pt	0.050733	0.021584
Non-carcinogens	Pt	0.058357	0.024587
Terrestrial ecotoxicity	Pt	0.368729	0.155266
Global warming	Pt	1.161532	0.495859
Respiratory inorganics	Pt	1.629976	0.688199
Non-renewable energy	Pt	7.770752	3.427264

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

IMPACT 2002+ was used to analyze the damage categories. Human health, Ecosystem quality, Climate change and Resources were found to be considered as damage categories (Table 2). Also Figure 7 show the single score in term of damage categories of Al-Daura refinery. According to Figure 7, Human Health, and Climate change are much more important than the damage on Ecosystem Quality. Gasoline total damage was equal to (11.1 Pt), compare to kerosene (4.83 Pt), the total refining damage categories are shown in Table 2.

4.3. Contribution Analysis

Contribution analysis is a significant tool used to understand the uncertainty of results. This analysis help in determine the process of significant role in your result. Frequently we have a LCA consists of 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 two as follow:

1) Contribution analysis section of the result screen (see Table 3).

2) Graphical representation of the process tree or network: the relative contribution of each procedure can be evaluated by using the tree procedure. This methodology has benefit represented in getting the exact role of the procedure in the life cycle (Figure 8 and Figure 9).

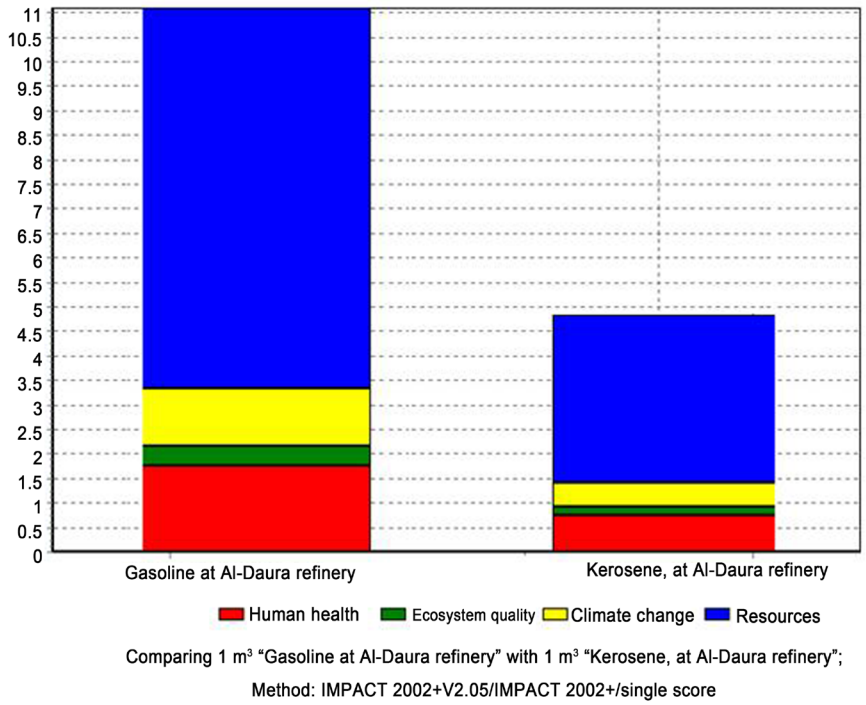

Figure 7. Single score in term of damage categories.

Table 2. Single score in term of damage categories.

Damage category	Unit	Gasoline at Al-Daura refinery	Kerosene, at Al-Daura refinery
Total	Pt	11.09088	4.834182
Ecosystem quality	Pt	0.408304	0.171959
Climate change	Pt	1.161532	0.495859
Human health	Pt	1.749961	0.73896
Resources	Pt	7.771082	3.427403

Table 3. Process contribution.

Process	Unit	Gasoline at Al-Daura refinery	Kerosene, at Al-Daura refinery
Total of all processes	Pt	11.09088	4.834182
Refinery gas, at refinery/RER S	Pt	10.84757	4.559665
Gasoline at Al-Daura refinery	Pt	0.214015	-
Steam, for chemical processes, at plant/RER S	Pt	0.025943	0.029269
Electricity, at refinery/RER S	Pt	0.002227	0.002512
Heavy fuel oil, at regional storage/RER S	Pt	0.001124	0.001291
Carbon tetrachloride, at plant/RER S	Pt	3.57E-07	4.03E-07
Disposal, refinery sludge, 89.5% water, to sanitary landfill/CH S	Pt	5.09E-08	5.74E-08
Dimethyl sulphate, at plant/RER S	Pt	7.02E-09	5.15E-09
Sodium hydroxide, 50% in H_2O, production mix, at plant/RER S	Pt	2.49E-09	2.81E-09
Kerosene, at Al-Daura refinery	Pt	-	0.241445

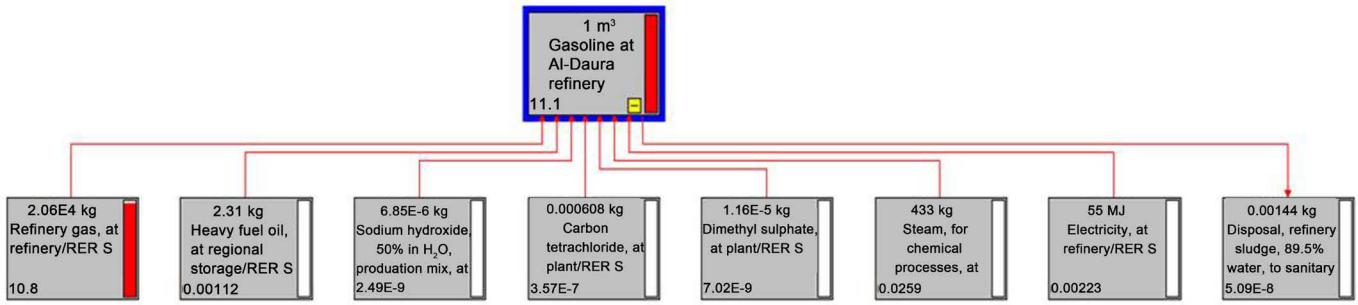

Figure 8. Process contribution of gasoline.

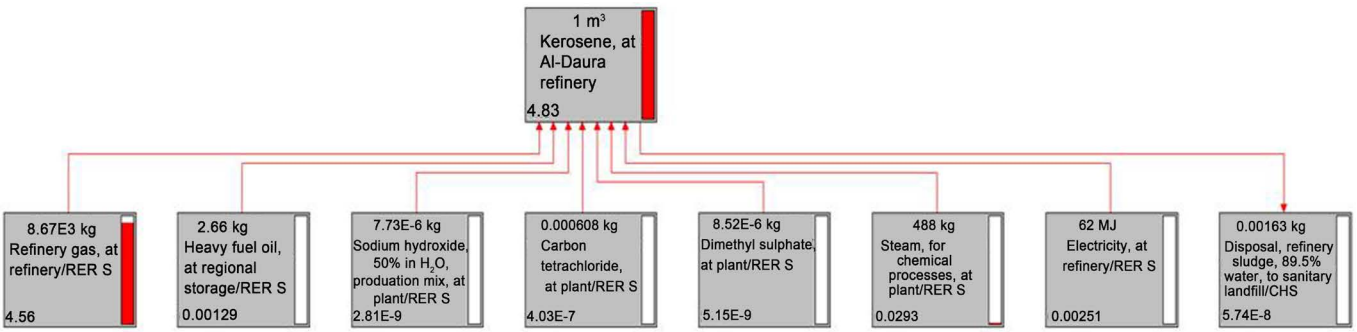

Figure 9. Process contribution of kerosene.

5. Conclusion

In this research, Simapro7 software was used to evaluate environmental indicators for gasoline and kerosene production in Al-Daura refinery. For this purpose, the IMPACT 2002+ was applied. The results indicated that the single-score on gasoline production was 11.1 Pt compared with 4.83 Pt for kerosene. The most environmental impact potential was global warming, respiratory in organics and non-renewable energy.

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