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EVALUATION OF ENVIRONMENTAL SUSTAINABILITY INDICATORS OF NORTHERN RUSTIMEH WASTEWATER TREATMENT PLANT IN BAGHDAD, IRAQ, USING SIMAPRO7.1 PROGRAM

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Abstract: The importance of the management of wastewater treatment plants is the process of purification of wastewater from impurities, suspended materials, pollutants and organic matter to be re-usable (non-human) or to be suitable for disposal in the waterways without causing pollution. Wastewater treatment involves several physical, chemical and biological phases. Because any wastewater treatment plant (WWTP) has environmental risk and negative impact, it is necessary to assess environmental sustainability indicators and thus can diagnose their risks and find solutions to reduce their environmental and health impacts in order to preserve the essential elements of the environment (water, air and soil) and on the conservation and sustainability of the natural resources of generations. There are many software programs designed to assess environmental sustainability indicators for any sewage treatment plant. SimaPro7.1 is one of several programs which are used to count and determine the ecological (environmental) effects related to wastewater treatment technologies. In this study, SimaPro7.1 has been used to inventory test namely the analysis of inputs to the plant, such as materials used in stage of construction of the plant, incoming wastewater, consumed energy, quality of treated wastewater and quantity of sludge produced, as well as the analysis of effluents to water and emissions air and assess an effects caused by Northern Rustimeh WWTP. An outcome from Life Cycle Assessment (LCA) shows the pollutant which emitted to all environment sub-compartment such as Carbon monoxide, Lead, Dinitrogen monoxide and another pollutant which causes impacts and damages to environment by 12.4GPt to every ($1m^3$) of sewage. The results show that generality effects were (global warming, respiratory inorganics and nonrenewable energy); also most damages were on human health, climate change and resources.

Keywords: *Wastewater Treatment Plant, Sustainability, Environmental Sustainability Indicators, Life Cycle Assessment, SimaPro7.1.*

تقييم مؤشرات الاستدامة البيئية لمحطة الرستمية الشمالي لمعالجة مياه الصرف الصحي في بغداد ، العراق ، باستخدام برنامجSimaPro7.1

الخلاصة: تكمن أهمية أدارة محطات معالجة مياه الصرف الصحي بكونها عملية تنقية مياه الصرف من الشوائب والمواد العالقة والملوثات والمواد العضوية لتصبح صالحة لإعادة الاستخدام (غير الآدمي) أو لتكون صالحة للتخلص منها في المجاري المائية دون أن تسبب تلوثا لها. تشتمل عملية معالجة الصرف على عدة مراحل فيزيائية وكيماوية وبيولوجية. لأن أي محطة لمعالجة مياه الصرف الصحي لها مخاطر بيئية

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وأثر سلبي ، فمن الضروري تقييم مؤشرات الاستدامة البيئية، وبالتالي يمكن تشخيص مخاطرها و إيجاد الحلول للحد من آثارها البيئية والآثار الصحية من أجل الحفاظ على العناصر الأساسية للبيئة (الماء والهواء والتربة) وحفظ واستدامة الموارد الطبيعية للأجيال القادمة. هناك العديد من البرامج المصممة لتقييم مؤشرات الاستدامة البيئية لأي محطة لمعالجة مياه الصرف الصحي. SimaPro7.1 هو واحد من العديد من البرامج التي تستخدم لحساب وتحديد الآثار البيئية المتعلقة بتكنولوجيات معالجة مياه الصرف الصحي. في هذه الدراسة استخدمنا SimaPro7.1 لتحليل المخزون أي تحليل المدخلات الى المحطة كالمواد المستخدمة في مرحلة أنشاء المحطة ومياه الصرف الصحي الداخلة والطاقة المستهلكة وكمية مياه الصرف الصحي المعالجة وكمية الحمأة الناتجة أضافة الى تحليل الأنبعاثات الى الماء و الهواء وتقييم الآثار الناجمة عن محطة الرستمية الشمالي لمعالجة مياه الصرف الصحي. تظهر نتيجة تقييم دورة الحياة الملوثات التي تنبعث إلى جميع عناصر البيئة مثل أول أكسيد الكربون والرصاص وأول أكسيد النيتروجين وملوثات آخرى تتسبب في حدوث تأثيرات وأضرار للبيئة بنسبة 12.4 جيجابايت لكل متر مكعب من مياه الصرف الصحي. أظهرت النتائج أن الأثار كانت (الاحتباس الحراري، الاثار غير العضوية في الجهاز التنفسي والطاقة غير المتجددة) ؛ أما بالنسبة للأضرار فكانت (صحة الإنسان وتغير المناخ والموارد).

1. Introduction

The Middle East is a water-mingy district, although water is not the only component that defines the remainder of Middle Eastern ecosystems. The conversation and ecological policy are somewhat new at Middle East. The ecological (environment) itself is very linked to politics; it defies resolution maker, and tasks or confrontation the daily lives of public at these nations [1]. Iraq, as one of the Middle East countries, is characterized by water supply and sanitation with poor water quality and services. Three decades of war combined with finite ecological consciousness, demolished Iraq's water resource administration systems. For this reason, Iraq confronts quandaries in meeting the goal for (91%) for households utilizing reliable potable water supplies, with 16 percent of households suffering from daily supply problems, 20 percent using unsafe drinking water [2]. Ecological administration is accountable to the maintenance and development of (ISO 14000) family for criterion, a commission currently has 21 global criterion and another kinds of standard document, Nine new and revised documents are also being prepared.

The International Organization for Standardization (ISO / TEC 207) was created at 1993 as an effect of the obligation of International Intellectual Property Organization for answer for tasks of improvement of sustainability in UN Congress in Environment and Improvement held at (Rio de Janeiro) in 1992. In 1991, Strategic Advisory Group on the Environment (SAGE) was founded after intensive consultative processes conducted with frames of the Strategically Advisory Combination at the Environment of the International Organization for Standardization, bringing together with reps from group of nations and global organization and about (100) ecological proficient who supported for explain how to use global criterion to help best ecological administration [3]. The set of standards (ISO 14000) provides tools to organizations and companies of various kinds that manage their environmental liabilities, the list of ISO 14000 series standards:

1. Ecological administration system (ISO 14001) demand together with instructions to utilize.
2. Ecological administration system (ISO 14004) basics guideline in execution .
3. Ecological management system (ISO 14006) guideline to integrating ecological layout.
4. Ecological evaluation for locations and organization (ISO 14015).
5. Ecological label and advertisement (ISO 14020) series.

6. Debates post product stage ecological evaluation ISO
7. Ecological rendering assessment Guideline (ISO 14031).
8. Lifetime Cycle evaluation, (ISO 14040 series) debates pre product designing and environment target adjusting series.
9. (ISO 14046) involves just air and soil releasing which effect water goodness in evaluation and group guidelines and requirement to water footprint evaluation of product, process and organization [4].

A reason for a change in current and future wastewater treatment systems to achieve sustainability is the high pressure of wastewater and the treatment of domestic wastewater. Sustainability obligates us to move towards optimal use of resources, but the favorable endurance of practices from sustainable to unsustainable requires tools that can warn against future trends. These tools reflect sustainability in a number of fields [5]. Life Cycle Assessment (LCA) ISO 14040, method has been proven to be used as a life cycle assessment application for the analysis and assessment of environmental impacts over the life cycle of wastewater treatment processes. It is an appropriate tool for evaluating wastewater treatment plant (WWTP) on sustainability. The overall approach to evaluating the sustainability of water services is a system analysis based on collective balances and energy that provides an indication of the use of materials, emissions, costs and required land area [6]. Life cycle assessment in terms of principle is kind for systems test utilizing index for assess effects on environment. It can be step to characterize the life cycle assessment, adding different environmental burdens to environmental issues useful for assessing the environmental performance index and the assessment step in which different environmental issues may be distributed, be useful in selecting different indicators. The Lifetime Cycle Evaluation phase is helpful step because it aims for resemble and quantify the almost significant utilizes of resources and emissions. And thus can identify the relevant processes that cause the most disturbing environmental loads [5].

The major aim of this research is to study the environmental indicators for Northern Rustimeh WWTP and compare them with Iraqi standards, also to analyze the environmental impacts and damages by LCA method using SimaPro7.1 software.

2. Methodology

2.1. Wastewater Treatment Plant (WWTP)

The Northern Rustimeh WWTP, which lies in the side of Rusafa/Baghdad Capital of Iraq was operated in 1984 and has a design capacity of 300,000 m^3 / day and an actual capacity of 250,000-300,000 m^3 / day, serves the 1,500,000 residents of the east of ALqanat canal, this project is consist of 2 lines for treatment **[7]**. Figure 1 show the location of the city of Baghdad in Iraq, figure 2 shows the location of Northern Rustimah WWTP in Baghdad and figure 3 shows Northern Rustimeh WWTP from the Top **[8].**

Figure 1. Show the location of the city of Baghdad in Iraq [8]

Figure 2. Show the location of Northern Rustimah WWTP in Baghdad [8]

Figure 3. Show Northern Rustimeh WWTP from the Top [8].

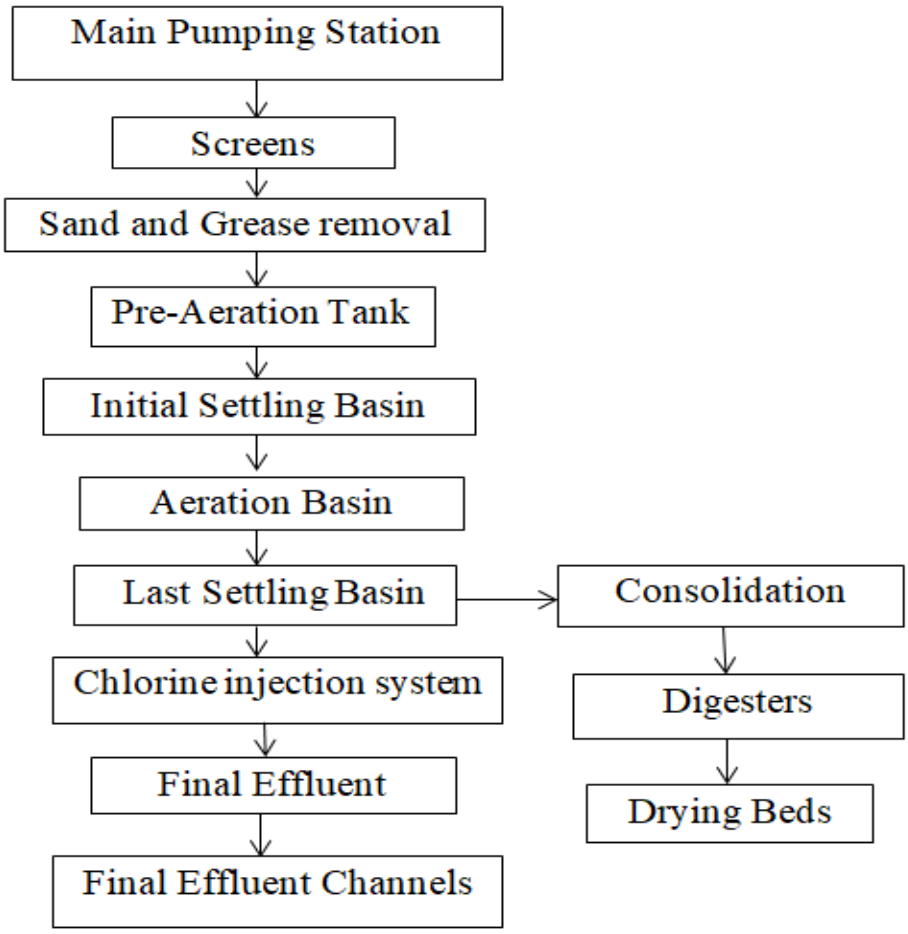

Figure 4. Flow Chart of Northern Rustimeh WWTP

The plant consists of the following units:

1. Main Pumping Station: There are 7 pumps as first stage and another 7 pumps as second stage.
2. Screens: The wastewater is passing through coarse screens then through fine screens.
3. Sand and Grease Removal: There are 3 chambers for each line.
4. Pre-Aeration Tanks: 2 tanks for each line.
5. Primary Settling Tanks: There are 6 settling tanks for each line.
6. Main Aeration Tanks: For each line there are 8 aeration tanks.
7. Final Settling Tanks: 8 settling tanks for each line.
8. Chlorine injection system: 4 channels for each line.
9. Final Effluent Station.
10. Final Effluent Channels.
11. Consolidation Tank: 2 tanks for each line.
12. Digesters: There are 6 digesters for each line.
13. Drying Beds.

Figure 4 shows a diagram of the treatment units Northern Rustimeh WWTP.

Table 1 Explain indicators, specifications of Influent and Effluent of the Northern Rustimeh WWTP with Effluent Standards and percentage of removal.

Table 1. Specifications of Influent and Effluent of the Northern Rustimeh WWTP with Iraqi Effluent Standards

Indicator	Influent	Effluent	Iraqi Effluent Standards	% Removal
Discharge(m^3/day)	300000	300000		---
pH	7.36	7.55	6-9.5	---
Temperature (°C)	22	22	<35	---
BOD (mg/l)	220	30.25	<40	86.25
COD (mg/l)	300	40	<100	86.67
TDS (mg/l)	1217	1027		18.5
Nitrate (mg/l)	6.6	4.3	50	34.85
Phosphate (mg/l)	17.6	2.4	3	86.36
Sulphate (mg/l)	448	442	400	---
Chloride (mg/l)	664	302.9	600	54.9
TSS (mg/l)	300	31.6	60	89.5

Source: Northern Rustimeh WWTP

2.2 SimaPro7.1 Methodology

To determine and evaluate the environmental effects and damages caused by wastewater treatment operation at Northern Rustimeh WWTP, SimaPro7.1 has been used.

Lifetime Cycle Evaluation step is constructed using SimaPro7.1 according to (ISO14040) (ISO14044) LCA criterion [9].

2.2.1 Definition of target and domain in SimaPro7.1

There is a particular section to illustrate the target and domain of every plan, and there are three parts and these involve:
First: text fields in which the various parts for definition of target and domain that can be described, where the version recorded here can be reproduced and stick for register.
Second: the library section, through which libraries with typical data that are connected to the project can be identified.
Third: The data quality department, through which the quality of the information (data) can be, defined in advance [10].

2.2.2 Inventory Analysis in SimaPro7.1

The test of inventory includes parameters to explain resources utilizes, material uses, and emission to water and air. In addition to the information we collect from WWTP in terms of inputs and outputs from plant, SimaPro7.1 program can be used to predict the pollutants emitted to all components of the environmental presidential by two methods; (Selected LCI results and Selected LCI results, additional), Figure 5 explain data which collected from Northern Rustimeh WWTP.

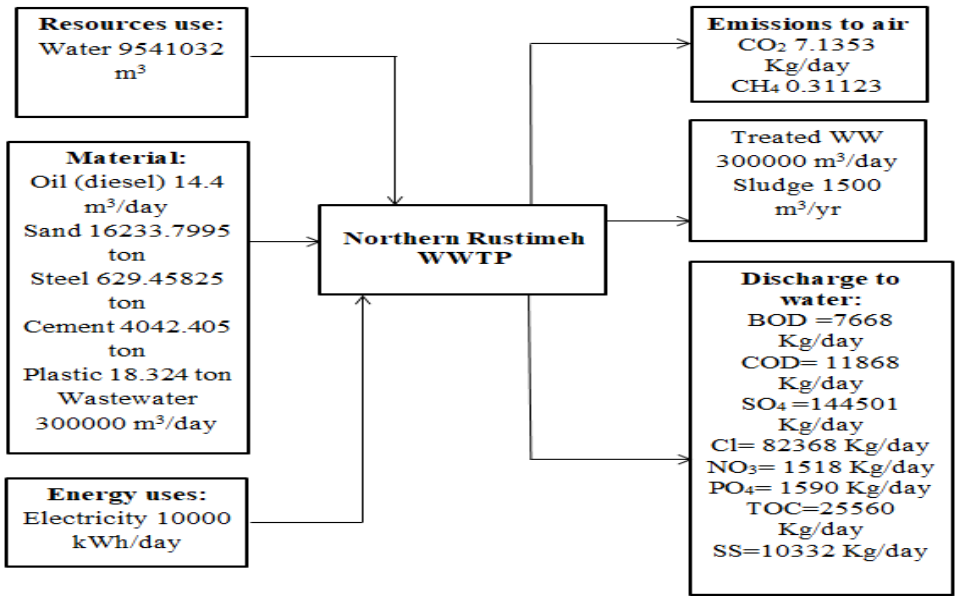

Figure 5. Inventory Analyses of Northern Rustimeh WWT Units.

2.2.3. Effect Evaluation in SimaPro7.1

There exist large varieties of effects evaluation ways ready at SimaPro7.1. Major framework of effect evaluation method at SimaPro7.1 is description (characterization),

damage evaluation, equalization (normalization) and weighting. The IMPACT 2002+ is a method of SimaPro7.1 was used to calculate the ecological impacts and damages of Northern Rustimeh WWTP. Current methodology suggests a proper performance of composite impacts and damages way, connecting every kinds of lifetime cycle inventory outcome (primary inflows and another mediation) via (14) impact groups for (4) damages groups, figure 6 show all sketch of (IMPACT 2002+) frame, connecting LCI outcomes via impact groups to damages groups.

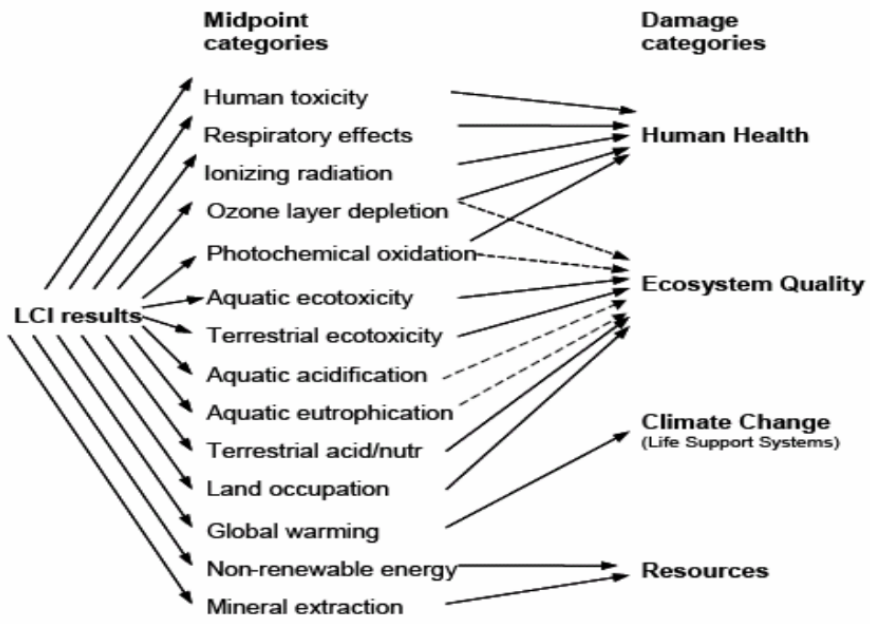

Figure 6. All Sketch of IMPACT 2002+ Frame, connecting LCI result via impacts groups to damages groups

2.2.4. *Interpretation at SimaPro7.1*

It is prepared as checklist who covering the pertinent issue mentioned at (ISO criterion utilized. As proposed through (Pre Consultants, 2006), observations are filled in when LCA research is about to be achieved and conclusion made**.**

3. Discussion and Results

In this research, the results were divided into two sections. The first section presents the pollutants emitted from Northern Rustimeh WWTP to all components of the environment. The second section includes the presentation of the effects and environmental damage caused by Northern Rustimeh WWTP.

3.1. Substances which Emitted from WWTP

List of appointed LCI (life cycle inventory) index is consist of 2 groups. Prime index includes usual series of primary inflows, second list contains additional elementary. These 2 lists are accomplished as 2 various ways in SimaPro7.1: (Selected LCI results

and Selected LCI results, additional). A contaminations and resource are appointed in view of a best description (characterization) of tested product and service.
The following tables 2 and 3 shows the first and second groups of substances that emitted to environment from Northern Rustimeh WWTP:

Table 2. Comparing 1m3 "Northern Rustimeh WWTP" by Selected LCI results V1.00, Characterization.

Impact category	Unit	Northern Rustimeh WWTP
NMVOC	kg	2.19E+10
Carbon dioxide, fossil	kg	4.14E+13
Sulphur dioxide	kg	5.98E+10
Nitrogen oxides	kg	1.07E+11
Particulates, <2.5 um	kg	1.84E+10
Land occupation	m2a	2.5E+12
BOD	kg	3.93E+10
Cadmium	kg	10507.45

Table 3. Comparing 1m3 "Northern Rustimeh WWTP" by Selected LCI results, additional V1.01, Characterization.

Impact category	Unit	Northern Rustimeh WWTP
Carbon monoxide	kg	1.87E+11
Carbon, biogenic, fixed	kg	-8.5E+10
Dinitrogen monoxide	kg	4.48E+08
Methane	kg	6.71E+10
Lead	kg	80928785
Zinc	kg	1.47E+08
Particulates	kg	1.06E+11
Particulates >10 um	kg	5.25E+10
Particulates, >2.5 um and <10	kg	3.48E+10
Heat, waste	MJ	4.26E+14
Oils, unspecified	kg	1.59E+10
Aerosole	kBq	9.77E+09
Actinides (air)	kBq	2.62E+09
Actinides (water)	kBq	1.34E+11
Noble gas	kBq	1.69E+15
Nuclides	kBq	2.16E+11
Radon	kBq	3.53E+15
Radium	kBq	3.47E+11
Tritium	kBq	7.54E+13
Water	m3	1.22E+14

The results in the tables above shows that Carbon dioxide is the most emitted followed by Carbon monoxide and Nitrogen oxides. Also the Particulate and the Particulate >10 um are emitted more than other types. For the radioactive materials, the most Radon element was emitted, followed by Noble gas and then Tritium of particulates.

3.2. Impacts and Damages Assessment

The Northern Rustimeh WWTP impacts and damages are analyzed by IMPACT2002+ method in SimaPro7.1 software. The objective of impacts and damages assessment is to assess the impact of the life cycle on the conversion of LCAI results to related environmental effects and damage and impacts on the use of natural resources, the natural environment and human health [11]. The result of Lifetime Cycle Evaluation had to be explained or weighted. The IMPACT2002+ method and Lifetime Cycle Evaluation weighting way expanded to products layout, this way had showed to be strong implement to planners for grouping Lifetime Cycle Evaluation results at simply clear and operator affable number or unit, the so named IMPACT2002+ Evaluation of Chemical Poisonous. Figure 7 explains international eco score in term of effect sections in Northern Rustimeh WWTP.

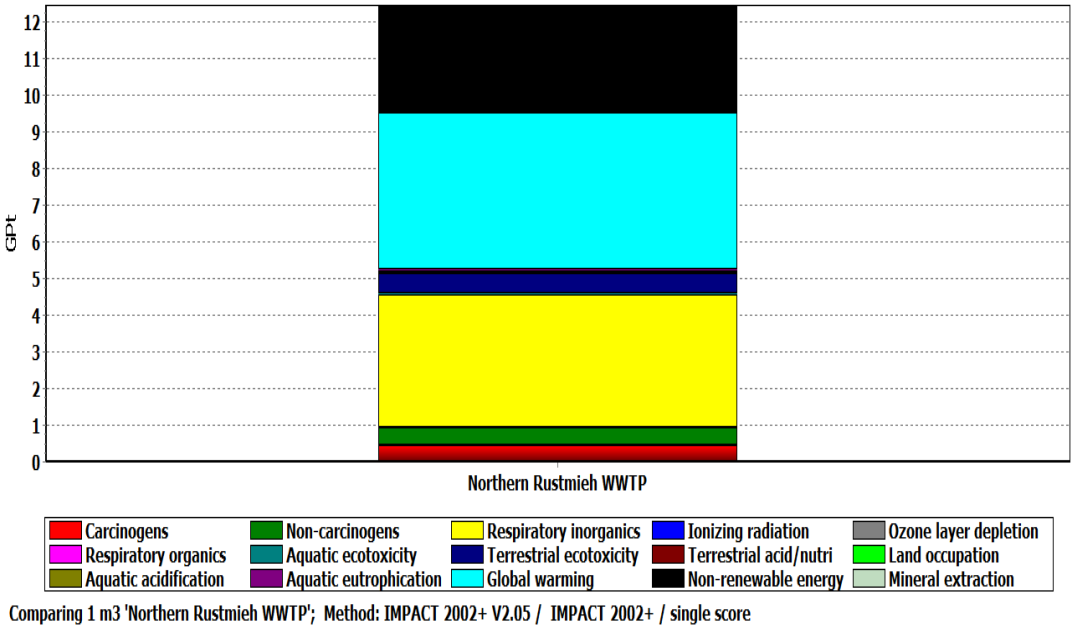

Figure 7. Global Eco-score in term of Effect Sections.

It is noted from figure 7 the most possible ecological effects are international warming followed by respiratory inorganics and nonrenewable energy. To the Northern Rustimeh wastewater treatment plant, 4.27GPt global warming, 3.64GPt respiratory inorganic and 2.9GPt non-renewable energy of total impact 12.4GPt.

The damage sections are examined by IMPACT2002+ method. Four sections of damage were indicated: People Health, Ecosystem Type Climate Variation and Resource. Each damage category consists of a number of damages categories all measured in the same units, Giga point (GPt).

Figure 8 shows global eco-score of damages section for each WWTP.

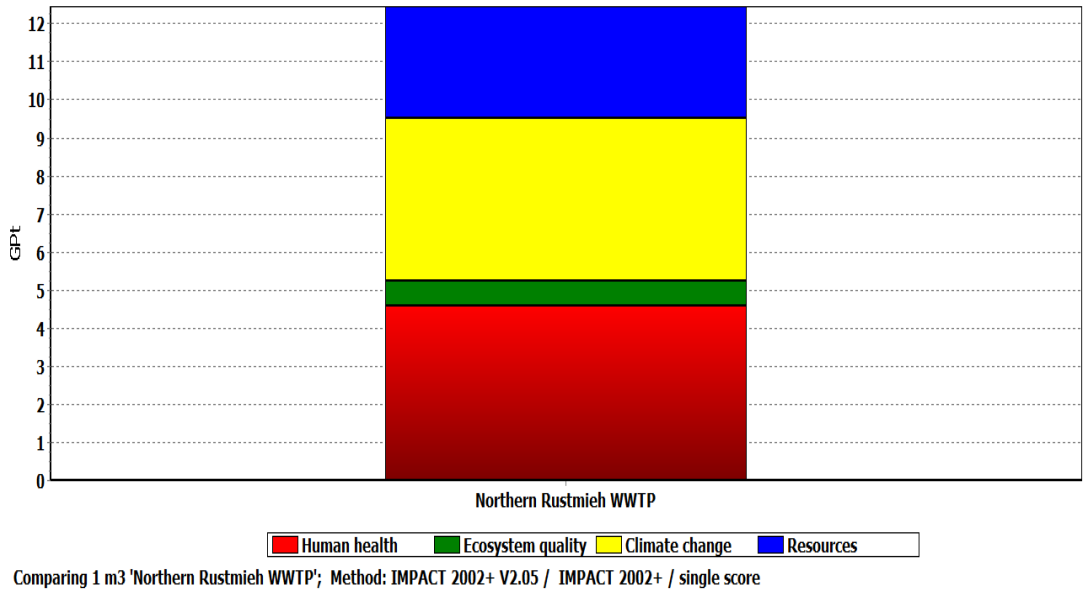

Figure 8. International Eco score of Damages Groups

The result from figure 8 shows that the environmental damage on people health is higher than other categories, followed by climate change and resources, for the Northern Rustimeh WWTP 4.58GPt on human health, 4.27GPt on climate change and 2.94GPt on resources.

The following table shows the processes contributing to effects and damages, so it noted that the sewage water entering the plant is the most influential factor on the environment followed by the cement, which is used during the plant construction period.

Table 4. The processes contributing to those effects

Process	Unit	Northern Rustimeh WWTP
Wastewater to treatment plant	Pt	1.23E+10
Cement	Pt	1.28E+08
Electricity	Pt	1.927071
Steel	Pt	0.495685
Sand	Pt	0.018542
Plastic	Pt	0.015143
Diesel	Pt	0.007136
Treated Wastewater	Pt	-0.02527
Sludge	Pt	-6377.41

4. Conclusions

In this study and by (Selected LCI results and Selected LCI results, additional) methods it can show the pollutants which emitted from Northern Rustimeh WWTP such as Carbon dioxide, Particulates and Lead that have a negative impact on the environment. Also, the IMPACT 2002+ method was used to evaluate the impacts and damages of the Northern Rustimeh WWTP, the results indicated that international eco score in Northern Rustimeh wastewater treatment plant was 12.4GPt. The almost ecological effect possible

is global warming followed by respiratory inorganic and non-renewable energy contributing to the Northern Rustimeh WWTP, also the most environmental damage is on human health, followed by climate change and resources. The wastewater, which entering the plant is the most influential factor on the environment followed by the cement, which is used during WWTP construction period.

Acknowledgement

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5. References

1. Samuel, W. (2013). *"The Environmental Challenges Facing the Middle East"*.
2. IAU - Inter-Agency Information and Analysis Unit. October (2010). Water in Iraq.
3. The ISO 14000, (2009). *"Family of International Standards Environmental Management"*. Geneva.
4. ISO 14000, https://en.wikipedia.org/wiki/ISO_14000.
5. Thitirut, C., (2005) *"Appraisal of Environmental Sustainability Indicators on the Conventional Sewerage and Domestic Wastewater Treatment Systems in Thailand: Case Study in Bangkok City"*, M.Sc. Thesis, Asian Institute of Technology School of Environment, Resources and Development Thailand.
6. Balkema, A. J., Preisig, H. A., Otterpohl, R. and Lambert, F. J. D. (2002) *"Indicators for sustainability assessment of wastewater treatment systems"*, Urban water, Vol. 4, Issue.2.
7. Management of Northern Rustimeh WWTP (2016).
8. Google Maps Application.
9. Negelah S., (2008) *"A Life Cycle Assessment of Sewage Sludge Treatment Option"*. MSc, thesis, Aalborg University, Denmark.
10. Rolf .F & Niels. J. (2007) *"Implementation of Life Cycle Assessment Methods"*, Swiss Center for Life Cycle Inventories.
11. Lehtinen O, Kotakoski J, Krasheninnikov A V, Keinonen J. (2011) "*Cutting and Controlled modification of grapheme with ion beams"*, Nanotechnology, Vol. 22, NO. 17.