

Assessment Of The Environmental Impacts Resulting From The Presence Of Surface Agents  
In The Discharge From An Urban Water Cleaning Station In Algeria

By  
The Life Cycle Assessment Method

M.Belkhir, K.Louhab, S.Bougherara

Research Laboratory on Food Technologies (LRTA), Faculty of Engineering Sciences,  
University M'Hamed Bougarra, 35000 Boumerdes, Algeria.

\*Corresponding author: [belkhirmeriem4@gmail.com](mailto:belkhirmeriem4@gmail.com)/ [m.belkhir@univ-boumerdes.dz](mailto:m.belkhir@univ-boumerdes.dz); Tel.: +213 24 91 11 16; Fax: +213 24 91 11 16

---

## ARTICLE INFO

### Article History:

Received : 00/00/2020

Accepted : 00/00/2020

### Key-Words:

Surfactants, wastewater, Simapro8.1, Impact, treatment,

---

## ABSTRACT/RESUME

**Abstract:** *The poor assessment of the environmental performance of water treatment systems led us to apply the life cycle assessment approach to a wastewater treatment plant. The purpose of our work is to evaluate the environmental impacts of the surfactants release from an existing urban wastewater treatment plant with a capacity of 35000 m<sup>3</sup>/inhabitant located in the city center of Boumerdès 45 km from the capital Algiers*

*The article presents an evaluation of the environmental impacts of the surfactants release. This evaluation was established using Simapro8.1 software and the Midpoint ILCD version 1.03 methods.*

*The results of evaluation show four impact categories are evaluated; - Human toxicity, Fresh water eutrophication, Marine eutrophication and Fresh water ecotoxicity. All the impact categories evaluated contribute to the surfactants fixed in the functional unit alcohol ether sulfate (AES), hexadecyl trimethyl bromide ammonium (CTAB) and Betaine of lauramidopropyl (BLP) of three different anionic, cationic and amphoteric types, respectively.*

*Finally, we conclude from the results obtained that the value of the impact of ecotoxicity is the highest (3, 24E-4 CTUe) compared to the other impact categories whose impact category represents the impact significant.*

---

## I. Introduction

In recent decades, the role of purification systems has become profoundly diverse. A significant number of synthetic contaminants, classified as "emerging pollutants". Among them, biocides and detergents with surfactant properties are of particular concern because of their ubiquity and their widespread use in domestic and industrial applications (1).

These substances can be grouped, according to their charge, in several families, among which the anionic surfactants, the cationic surfactants, the nonionic surfactants and the zwitterionic surfactants (2).

Few surfactant measurements in wastewater effluents have been undertaken. Surfactant concentrations of up to 872 µg/L for alkylbenzene sulfonate (LAS) (3) and 0.9 to

964  $\mu\text{g/L}$  for alkylphenol ethoxylates have been reported (4).

Life cycle assessment is a tool for the systematic analysis of the environmental performance of a product or its processes, including raw material extraction and manufacturing, often considered a cradle-to-grave approach. For the assessment of environmental impacts (5,6). Life Cycle Assessment (LCA) is a powerful tool for analyzing the environmental impacts associated with a product, process or service by creating an inventory of applied inputs and releases to the environment (7, 8).

LCA is a standardized method. The International Organization for Standardization (ISO) adopted an environmental management standard in the 1990 as part of its series of 14,000 standards. (9,10).

## II. CASE STUDY DESCRIPTION

In order to avoid the problems of data collection, we chose to apply LCA on an existing wastewater treatment plant, it is a fairly recent station based on activated sludge treatment. With a capacity of 75000 Eq/Hab. Wastewater arriving at the station is pre-treated (screening, degreasing, grit removal) and then sent for biological treatment. Biological treatment is carried out in activated sludge tanks equipped with a bridging system. This arrangement ensures the treatment of organic pollution. The extracted sludge is thickened by flotation and then stored and packaged in a maturation tarpaulin.



Figure 1: Situation of the bumerdes station

### III. METHODOLOGY OF THE ASSESSMENT

The LCA methodology assesses the environmental impacts generated by the treatment plant. In this study, LCA is applied to evaluate the environmental impacts generated by the treatment process of the treatment plant.

#### III.1. Goal and scope definition

The purpose of this study is to evaluate the treatment of activated sludge surfactants in the step to identify the environmental impacts contribute to the rejected surfactants, by applying the LCA approach. The analysis of which was fixed on three surfactants of different types (AES, CTAB and BLP).

The functional unit chosen for this study is the flow of water treated by step by day 35000m<sup>3</sup>.

#### III.2. Software and method

The primary energy demand and the environmental loads of the water treatment and end-of-life phases of the materials were quantified using the SimaPro 8.01 LCA software (11). The majority of the inventory data has been extracted from the Midpoint Version 1.03 ILCD database (12). Midpoint is a comprehensive database used in many LCA, including Iqbal et al. (13).

#### III.3. life cycle impact assasement

- Consumables

In this study we chose to evaluate the station on four impacts:

- Human toxicity
- Fresh water eutrophication.
- Marine eutrophication.
- Fresh water ecotoxicity.

For each impact, the result part will contain the following elements:

- A presentation of the impact assessment results.
- The results will be interpreted and discussed.

#### III.4. Life cycle inventory

The complete inventory of pollutant emissions and consumption of the natural resources of the step is corresponding to the average of the parameters resulting from canceled reports provided by the operator for the year 2017.

- Energy

The daily electricity consumption of the station per day is 39330kwh/day.

Table1: The consumption of the reagents of the station

Reagents	Quantity( kg/day)
Ca (OH) <sub>2</sub>	23.00
FeCl <sub>3</sub>	05.00
H <sub>3</sub> PO <sub>4</sub>	06.00
NH <sub>3</sub> OH	25.50
NaOH	13.50
HCIO	20.00
H <sub>2</sub> SO <sub>4</sub>	03.50
HCl	08.50

## ➤ Flow input and output of the station

The flows entering and leaving this study are presented by the raw water entering the station and the treated water of the station. They are characterized by the physicochemical parameters of pollution and three types of agents of anionic surfactant AES, cationic

CTAB and amphoteric BLP to allow us to evaluate the impacts contribute to this molecules.

The table below represents the analytical parameters of the raw water and the treated water of the station; the values considered are the means of the parameters during the year 2017.

Table 2: Analytical parameters of the raw and treated water of the station

Paramètres	BOD5	COD	MES	NTK	NO <sub>2</sub>	NO <sub>3</sub>	AES	CTAB	BLP
Unit	mg O <sub>2</sub> /l	mg O <sub>2</sub> /l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
<b>raw water</b>	298.20	810.00	379.00	57	0.1	0.9	677.13	50.86	19.36
<b>treated water</b>	89.00	251.00	110.00	3.00	2.30	17.00	547.18	44.25	16.64
<b>Efficience %</b>	70.13	69.01	70.79	94.73	-	-	15.76	13.66	19.33

The low efficiency of surfactant treatment is their adverse effects on the operation of sewage treatment plants. Let them be summarized in two points; the first is the effect on the filtration process and the second on the biological treatment process.

- The effect of the surfactants on the filtration results in an increase in the pressure loss, it was found that during sand filtration, which constitutes the final stage of the purification process, a concentration greater than 20 mg.L<sup>-1</sup> of surfactant affects the efficiency of filtration for the removal of bacteria and flocs from subsequent treatments (14).
- Surfactants have a harmful effect on aerobic biological treatment because of the reduction of the oxygen transfer coefficient.

In this case, the microorganisms will not always have at their disposal the oxygen necessary for biodegradation (14, 15).

However some authors show that a decrease in the oxygenation coefficient of the order of 65% reduces the efficiency of the installation by 30%. Indeed, this study reported deterioration of bacterial beds starting from a concentration of 20 mg.L<sup>-1</sup> (16).

#### IV. RESULTATS AND DESCUTION

In this work we followed the method of Midpoint ILCD version 1.03, the impact calculation results tested by this method are shown in Table 3.

Table 3: Impact results calculated by the ILCD method

Impact category	Unit	Quantity of Impact	Observation
<b>Human toxicity</b>	CTUh( comparative unit of toxicity for humans)	2.03E-10	Evaluates the chronic toxicological effects on human health due to emissions of organic substances. Gives an estimate of the increase in morbidity across the entire human population.
<b>Fresh water eutrophication</b>	Kg P eq	3.76 E-6	This is the enrichment of water in nutrients.
<b>Marine eutrophication</b>	Kg N eq	3.87 E-6	This is the enrichment of water in nutrients. This causes asphyxiation of aquatic ecosystems.
<b>Fresh water ecotoxicity.</b>	CTUe (unit of ecosystem toxicity)	3.24 E-4	Evaluates the toxicity of the emission of substances on ecosystems. Characterizes the potential risks induced by the presence of chemical compounds in a specific ecological system.

### 1) Eutrophication

Eutrophication is an important impact for the field of sanitation; it is indeed one of represents from 80 to 95% of the total impact of the rejection of the station, the two types of eutrophication (nitrogen and phosphorus) are close together (3.76 E-6 kg P eq). In fact, phosphorus is less harmful in the eutrophication phenomenon than nitrates (3.87 E-6 Kg N eq). The results obtained show two categories of eutrophication one and fresh water explain by the rejection of the step towards the Oued and the second category is marine eutrophication.

the main functions of sewage treatment plants to fight against nitrogen and phosphorus pollution. This category of impacts

### 2) Toxicity

The impact of toxicity on human health is divided into two categories Human toxicity, the present method contributes the impact of human toxicity without carcinogenic effects to surfactants present in the releases to 2.03E-10 CTUh. And human toxicity contributes to the presence of surfactants; these elements constitute a risk to human health through contamination of the food chain.

### 3) Aquatic ecotoxicity

The impact of aquatic ecotoxicity affects fauna and flora in the same way as do toxic substances on human health the same molecules

contribute to the before are concerned; surfactants as organic pollution with an impact amount of  $3.24 \times 10^{-4}$  CTUe.

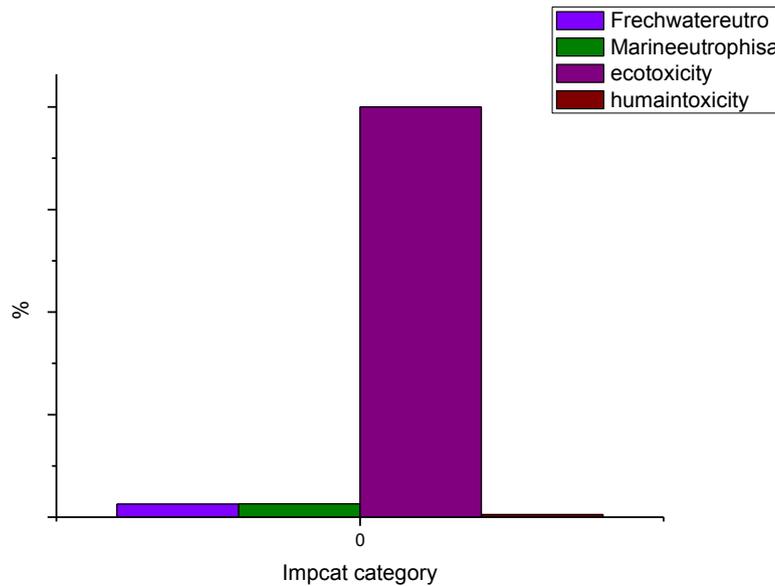


Figure 2: The impact results calculated by the ILCD method.

The impact assessment results show that the amount of ecotoxicity impact of freshwater is the highest with  $3.24 \times 10^{-4}$  CTUe,

In the literature, the toxicity of surfactants for the aquatic environment, and in particular the marine environment, is very poorly known (17). Of which the surfactants studied are LAS, sodium dodecyl sulfate (SDS), alkylethoxylate (AE) and dimethyl ammonium chloride (DTDMAC) (18, 19).

Most of the surfactant toxicity tests found in the literature describes in vitro alternatives for the purpose of studying gene distribution. Perez et al. Concentrates in their work on intrinsic toxicity testing of surfactants without consider specific applications. However in vivo tests in human volunteers are therefore crucial, at

least to confirm in vitro results. They identified five different categories of procedures used to measure the toxicity of surfactants (20).

Cationic surfactants have the highest aquatic toxicity compared to other surfactants (21). Because of their antimicrobial properties, they are frequently found in home-use detergents (22, 23, 24, 25, and 26).

Toxicity studies are primarily focused on assessing acute toxicity, which means assessing the lethal concentration 50%. Very few studies are interested in the effects of exposure of organisms to surfactants (27).

## V. CONCLUSION AND RECOMMANDATION

Wastewater treatment plants have a variety of processes, their treatment processes also generate different impact categories that are difficult to identify, which has led us to apply the LCA method. Indeed this method is multicriterion and more representative; it allowed us to evaluate the direct and indirect impacts of liquid discharge of the step.

It has emerged as the most suitable method for assessing environmental impacts in the water treatment sector. Our analysis is based on a case study of an existing station. We analyzed four impacts (Human toxicity, Fresh water eutrophication, Marine eutrophication and Fresh water ecotoxicity) after presenting the elements of the field of study, data and assumptions.

This experience shows a certain number of conclusions, firstly LCA appears as an essential tool for assessing environmental performance in the field of water treatment, the global impact eutrophication is evaluated in a robust way unlike the local impacts of toxicity and ecotoxicity that are sufficiently weak to address health issues in the field of sanitation, it is possible to complement and deepen the local impact assessment study with experimental studies.

## VI. REFERENCES

1. Ying, G. G., 2006. Fate, behavior and effects of surfactants and their degradation products in the environment. *Environ. Int.* 32, 417-431
2. Zhang C, Cui F, Zeng GM, Jiang M, Yang ZZ, Yu ZG, Zhu MY, Shen LQ (2015): Quaternary ammonium compounds (QACs): A review on occurrence, fate and toxicity in the environment. *Science of the Total Environment* 518, 352-362
3. Traverso-Soto JM, Lara-Martin PA, Gonzalez-Mazo E, Leon VM (2015): Distribution of anionic and nonionic surfactants in a sewage-impacted Mediterranean coastal lagoon: Inputs and seasonal variations. *Science of the Total Environment* 503, 87-96
4. Isobe T, Nishiyama H, Nakashima A, Takada H (2001): Distribution and behavior of nonylphenol, octylphenol and nonylphenol monoethoxylate in okyo metropolitan area: Their association with aquatic particles and sedimentary distributions. *Environmental Science and Technology* 35, 1041-1049
5. Lankey, R. L., & Anastas, P. T. (2002). Life-cycle approaches for assessing green chemistry technologies. *Industrial and Engineering Chemistry Research*, 41(18), 4498-4502
6. Joshi, S. (1999). Product environmental life-cycle assessment using input-output techniques. *Journal of Industrial Ecology*, 3(2-3), 95-120.
7. Tabatabaie, S. M. H., Tahami, H., & Murthy, G. S. (2018). A regional life cycle assessment and economic analysis of camelina biodiesel production in the Pacific Northwestern US. *Journal of Cleaner Production*, 172, 2389-2400.
8. EPA, 2016. United States Environmental Protection Agency. Available at: www.epa.
9. ISO 14040:2006. Environmental management – life cycle assessment
10. ISO 14044:2006. Environmental management – life cycle assessment
11. Tulevech, S. M., Hage, D. J., Jorgensen, S. K., Guensler, C. L., Himmler, R., & Gheewala, S. H. (2018). Life cycle assessment: A multi-scenario case study of a low-energy industrial building in Thailand. *Energy and Buildings*, 168, 191-200
12. Ecoinvent. Ecoinvent—The World's Most Consistent And Transparent Life Cycle Inventory Database, [online], available: ecoinvent.org (accessed 13.06.17).
13. M.I. Iqbal, R. Himmler, S.H. Gheewala, Environmental impacts reduction potential through a PV based transition from typical to energy plus houses in Thailand: a life cycle perspective, *Sustainable Cities*

- Soc. 37 (2018) 307–322. <https://doi.org/10.1016/j.scs.2017.11.028>.
14. Leclerc, E. (1977) « *Les détergents et la pollution des eaux* ». Eyrolles, Paris.
  15. Prats, D., Lopez, C., Vallejo, D., Varo, P., Leon, V.M., (2006). « *Effect of temperature on the biodegradation of linear alkylbenzene sulfonate and alcohol ethoxylate* ». Journal of Surfactant and Detergent. 9 1, 69–75. Principles and framework. CEN (European Committee for Standardisation), Res. J. 80, 1721e1737.
  16. Birch Ronald R (1992) Journ. of Chemical Technology and biotechnology 50 3 411 Brussels.
  17. Perez T., Sartoretto S., Soltan D., Capo S., Fourt M., Dutrieux E., Vacelet J., Harmelin J.G., REBOUILLON P. (2000). Etude bibliographique sur les bioindicateurs de l'état du milieu marin. *Système d'évaluation de la Qualité des Milieux littoraux – Volet biologique*. Rapport Agences de l'Eau, 4 fascicules, 642 pp
  18. Mariani, L., Pascale, D.De., Faraponova, O., Tornambe, A., Sarni, A., Giuliani, S., Rug-gero, G., Onorati, F., Magaletti, E., 2006. The Use of a Test Battery in MarineEcotoxicology: The Acute Toxicity of Sodium Dodecyl Sulfate. Wiley Inter-Science, pp. 373–379.
  19. Concetta Maria Messina\*,1, Caterina Faggiob,1, Vincenzo Alessandro Laudicellac,Marilena Sanfilippob, Francesca Trischittab, Andrea Santullia ; Effect of sodium dodecyl sulfate (SDS) on stress response in theMediterranean mussel (*Mytilus Galloprovincialis*): Regulatory volumedecrease (Rvd) and modulation of biochemical markers related tooxidative stress Concetta Aquatic Toxicology 157 (2014) 94–100gov (accessed 05.03.2017).
  20. Lourdes Pérez, Aurora Pinazo, Ramon Pons, MRosa Infante; Gemini surfactants from natural amino acids ;Advances in Colloid and Interface Science 205 (2014) 134–155
  21. Tehrani-Bagha, A.R., Oskarsson, H., van Ginkel, C.G., Holmberg, K., 2007. Cationic ester-containing gemini surfactants: chemical hydrolysis and biodegradation. Journal of Colloid and Interface Science312, 444–452.
  22. Tawfik, S.M., 2015. Synthesis, surface, biological activity and mixed micellar phase properties of some biodegradable gemini cationic surfactants containing oxycarbonyl groups in the lipophilic part.
  23. Levec, J., & Pintar, A. (1995). Catalytic oxidation of aqueous solutions of organics. An effective method for removal of toxic pollutants from waste waters. Catalysis today, 24(1-2), 51-58.
  24. Xue, Y., Xiao, H., Zhang, Y., 2015. Antimicrobial polymeric materials with quaternary ammonium and phosphonium salts. International Journal of Molecular Sciences. 16, 3626e3655.
  25. Mori, I.C., Arias-Barreiro, C.R., Koutsaftis, A., Ogo, A., Kawano, T., Yoshizuka, K., Inayat-Hussain, S.H., Aoyama, I., 2015. Toxicity of tetra methyl ammonium hydroxideto aquatic organisms and its synergistic action with potassium iodide. Chemosphere 120, 299e304.
  26. Simoncic, B., Tomsic, B., 2010. Structures of novel antimicrobial agents for textiles e a review. Text requirements and guidelines. CEN (European Committee for Standardisa
  27. Yaacoubi, A., Mazet, M., & Dusart, O. (1991). Competitive effect in bi-solute adsorption onto activated carbon: DSS, alcohols and phenols and solutes. *Water Research*, 25(8), 929-937