Appraisal of environmental impacts for a large-scale water treatment plant through life cycle assessment

H. Sahin Akkurt[1], N. Elginoz[2], G. Iskender[1], F. Germirli Babuna[1]

[1]Department of Environmental Engineering, Istanbul Technical University, Maslak 34469, Istanbul, Turkey
[2]Department of Civil Engineering, Istanbul Technical University, Maslak 34469, Istanbul, Turkey
Keywords: Environmental impact, life cycle assessment, water treatment, sustainability, operation.
Presenting author email: germirliba@itu.edu.tr

Being a metropolis, Istanbul requires a well-functioning urban service system. Water supply is among the most important infrastructures in this city that has around 15 million habitants. There are many water treatment plants all around Istanbul to facilitate healthy water supply to people. On the other hand, these plants are sources of environmental impacts. In this perspective, it is necessary to investigate the ways to reduce these negative environmental impacts.

The objective of this study is to evaluate the environmental impacts of Kagithane Water Treatment Plant (KWTP) by adopting life cycle assessment (LCA) methodology. KWTP is one of the biggest water treatment plants in Turkey. The treatment plant is located on the western side of Istanbul. It withdraws water from Terkos Lake and Alibey dam.

The treatment facility is composed of two parallel treatment plants which are constructed in different dates. At first Kagithane Yildirim Bayezid Water Treatment Plant (KYBWTP) is constructed. After a while since the water demand is increased, a parallel line is constructed, this second line is named as Kagithane Celebi Mehmet Water Treatment Plant (KCMWTP). As a result of the appraisal recommendations are made.

Life cycle assessment methodology having the following four stages of: i) goal and scope definition; ii) life cycle inventory; iii) life cycle impact assessment and; iv) interpretation of findings; is applied. The mentioned four phases are iteratively performed with feedbacks.

The scope of the study is the operation phase as it is indicated in literature that this is the main contributing phase to all investigated environmental impact categories (Friedrich and Buckley 2002). Therefore, construction and decommissioning stages of the facility is not covered in this study.

The operation of the plant covers main and sub treatment processes. The main processes of the plant are the screen, input/output pumps, aeration, ozonation, slow/rapid mixing, clarification, filtration, disinfection, reservoir and sludge transportation. The sub processes are chemical units, backwash water, blower, sludge pump unit and clarified water pump unit.

Data collected from the actual plant for about a year is to establish the inventory. The functional unit of the study is 1 m^3. The material usage, electricity consumption and transportation of chemicals are normalized for this functional unit.

Modelling is performed on GaBi software version 7.3 and Professional Database is used for background processes. CML 2001 is used for converting input and output flows to impact categories.

The following environmental impact categories are investigated: global warming potential (GWP), acidification potential (AP), eutrophication potential (EP), ozone layer depletion potential (ODP), abiotic depletion potential elements (ADP elements), abiotic depletion potential fossil (ADP fossil), freshwater aquatic ecotoxicity potential (FAEP), human toxicity potential (HTP), marine aquatic ecotoxicity potential (MAEP), photochemical ozone creation potential (POCP) and terrestric ecotoxicity potential (TETP).

About 0.76 kWh electricity is required to generate one cubic meter of treated water in the treatment plant. A high portion of this requirement is due to inlet (22 %) and outlet (63 %) water pumping stations.

The environmental impacts obtained in this study are given in Table 1. These findings are in accordance with the literature values listed for conventional treatment (Rodriguez et al. 2016; Zine et al. 2013; Bonton et al. 2012; Friedrich and Buckley 2002).

Electricity requirement is the most important contributor to all environmental impact categories. Therefore, strategies involving the reduction of electricity consumption or supplying electricity from renewable sources are recommended to decrease the impacts.

Table 1. Environmental impacts of the investigated water treatment plant

Environmental Impact	Total
ADP element(kg Sb - Equiv.)	1.51E-07
ADP fossil (MJ-Equiv.)	5.00
AP (kg SO_2-Equiv.)	8.16E-04
EP (kg PO_4-Equiv.)	6.78E-05
FAEP (kg DCB -Equiv.)	4.32E-04
GWP (kg CO_2 Equiv.)	3.92E-01
HTP (kg DCB Equiv.)	1.1E-02
MAEP (kg DCB Equiv.)	4.07E-01
ODP (kg R11 Equiv.)	24.43
POCP (kg Ethane-Equiv.)	4.37E-05
TETP (kg DCB -Equiv.)	1.71E-04

References

Friedrich, E. and Buckley, C. 2002. The use of life cycle assessment in the selection of water treatment processes. Water Research Commission (WRC) Report, (1077/1), 02.

Bonton, A., Bouchard, C., Barbeau, B. and Jedrzejak, S. 2012. Comparative life cycle assessment of water treatment plants. Desalination, 284, 42-54.

Rodriguez, O. O., Villamizar-Gallardo, R. A. and García, R. G. 2016. Life cycle assessment of four potable water treatment plants in Northeastern Colombia. Revista Ambiente & Água, 11(2), 268-278.

Zine, M. B., Hamouche, A. and Krim, L. 2013. The study of potable water treatment process in Algeria (boudouaou station)-by the application of life cycle assessment (LCA). Journal of Environmental Health Science and Engineering, 11(1), 37.