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Life cycle assessment of water treatment technologies: wastewater and water-reuse in a small town

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Abstract

This paper consists on a global environmental analysis of a waste water treatment (Conventional Activate Sludge System, CAS, designed for 13,200 population equivalent) and some possible additional tertiary treatments allowing water reuse to that purified waters (UF and immersed and external Membrane Biological Reactors, MBR). The environmental assessment of these water treatment technologies has been realized by means of the Life Cycle Assessment (LCA) technique, in order to establish with a broad perspective and in a rigorous and objective way the technology that provokes the lowest environmental load. The software SimaPro 5.1, developed by Dutch PRé Consultants, has been used as the LCA analysis tool, and three different evaluation methods—CML 2 baseline 2000, Eco-Points 97 and Eco-Indicator 99—have been applied. The results show that tertiary treatment does not increase significantly the environmental loads but provide new uses for that purified water, thus justifying the intensive use of water reuse techniques in water scarce areas.

Keywords: Life cycle assessment; Wastewater treatment; Water-reuse; Conventional activate sludge system; Membrane biological reactor

1. Introduction

In Europe the last two decades have witnessed growing water stresses, both in terms of water scarcity and quality deterioration, which has prompted many municipalities to look for a more efficient use of water

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resources, including a more widespread acceptance of water reuse practices [1]. The use of treated wastewater with high level of quality that, nowadays, are discharged to environment after their treatment in municipal sewage plants, needs a special attention as a new water resource. However, water reuse should not be viewed as simply as reclamation and reuse of wastewater effluents. Rather, a broader definition, encompassing the recovery and reuse of brackish ground waters, water harvesting and agriculture drainage flows, combined with seawater desalination, should be embraced [2].

First, it is important to distinguish between direct and indirect water reuse [3]. In inland catchments, wastewater with more or less treatment is discharged and dissolved in river beds or reservoirs that downstream can be indirectly reused again. It is not the same in coastal zones where wastewater is evacuated to sea by means of emissaries or river beds or aquifers, without any possibility of new uses. Consequently, it is in those coastal zones and inland areas with water scarcity where the implementation of the direct reuse and management of treated wastewater, by means of their collection, treatment and transport to the new use points and without pre-dilution in natural courses of water, is totally feasible.

Regarding water reuse techniques, water reuse has been developed from the most basic method of disposing wastewater without any treatment to often highly-engineered techniques of wastewater upgrading. In any case, water reuse already represents an important water supply in many areas of the world. For instance, nowadays it represents about 17% of the total purified wastewater in Spain: 408 hm^3/y are reused from 2400 hm^3/y discharged from sewage plants, and projections are limited to 1200 hm^3/y due to technical constraints [4].

The main objective of this study is to estimate or predict the environmental aspects and potential impacts associated to some water treatment technologies (wastewater and reuse) as a whole view of the technology less aggressive and harmful for the environment. First, the descriptions of the analyzed water treatment technologies are briefly presented. Then, the main results corresponding to the environmental loads of those technologies as well as a comparative analysis are presented. Finally, the main conclusions achieved are briefly commented.

2. Description of water treatment technologies

The great majority of sewage plants in Spain work with a conventional system of activated sludge. Thus, quality of purified water only fulfils the European Directive 91/271/CEE regarding the quality of secondary treatment discharges, and consequently it is not yet suitable for recycling. Thus, in order to be reused it is necessary to apply complementary (tertiary) treatments. The addition of UF membranes is a possible treatment; this technique has advanced so much that it has emerged a new concept of biological treatment of wastewater: Membrane Bioreactor (MBR) [5]. This new technology offers some advantages versus conventional processes used until now, including, reliability, compactness, and above all, the excellent quality of treated water.

The mission of a sewage plant is to reduce water pollution, that is:

- To eliminate wastes, oils, fatties, sands.
- To eliminate decantable organic and inorganic matter.
- To eliminate ammoniacal compounds containing phosphorous (particularly in vulnerable areas).
- To transform return wastes to stable sludge and to manage it adequately.