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REVIEW OF EXISTING LCA STUDIES ON WASTE WATER TREATMENT TECHNOLOGIES

ABSTRACT

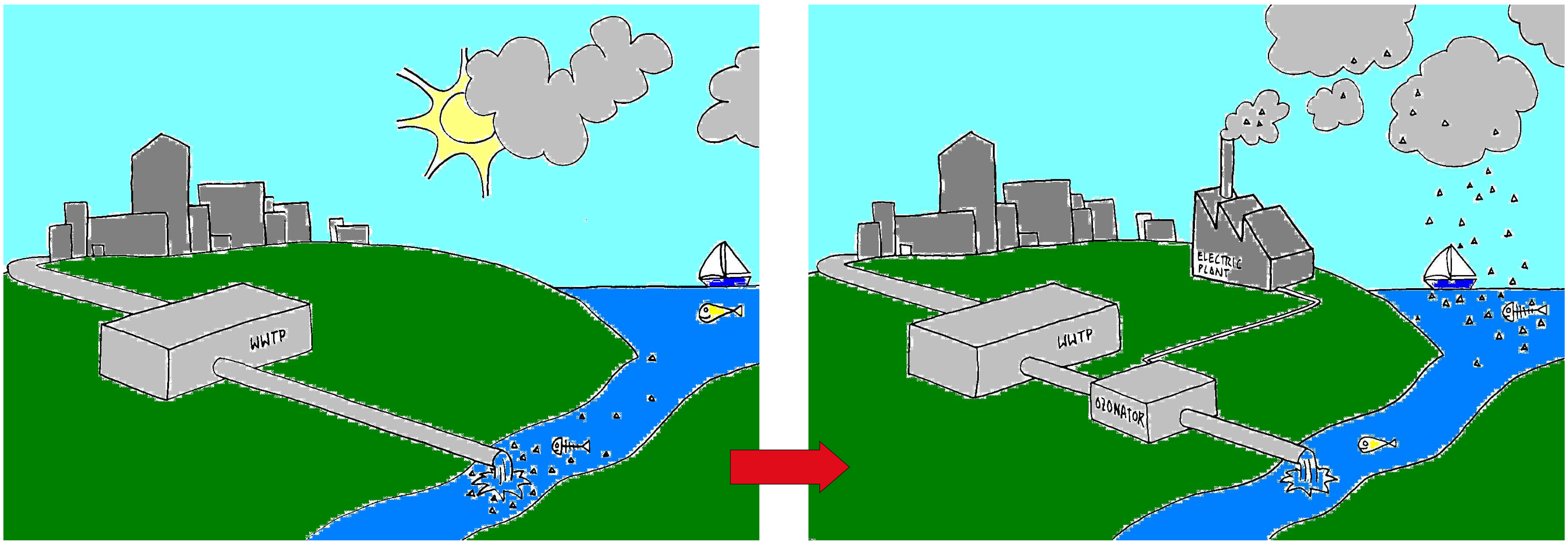
The EU research project "NEPTUNE" is related to the EU Water Framework Directive and focused on the development of new waste water treatment technologies (WWTT) for municipal waste water. The sustainability of these WWTTs is going to be assessed by the use of life cycle assessment (LCA). New life cycle impact assessment methods on pathogens, whole effluent toxicity and micropollutants will be developed within the project. As part of this work a review of more than 20 previous LCA studies on WWTTs has been done and the findings are summarised on this poster. The review is focused on the relative importance of the different life cycle stages and the individual impact categories in the total impact from the waste water treatment, and the degree to which micropollutants, pathogens and whole effluent toxicity have been included in earlier studies. The results show that more than 30 different WWTT (and even more treatment trains/scenarios) have already been the subject of more or less detailed LCAs. All life cycle stages may be important and all impact categories (except stratospheric ozone depletion) typically included in LCAs may show significance depending on the actual scenario. Potential impacts of pathogens and whole effluent toxicity have not been included in any study, and only a few studies have included micropollutants (in total less than 20 different micropollutants).

Background

This poster is based on a literature study (Larsen et al. 2007) done within the ongoing EU FP6 project NEPTUNE (www.eu-neptune.org). The background for NEPTUNE is the Water Framework Directive (WFD) (EC 2000, 2002) and the main goal is to develop new and optimize existing waste water treatment technologies (WWTT) and sludge handling methods for municipal waste water. A special focus area is micropollutants (e.g. pharmaceuticals and metals). The review of the 22 existing LCA studies, summarised in this poster, is used within NEPTUNE as a starting point for the LCA based development of a holistically based prioritisation among technologies and optimisations.

Types of studies included

Seventeen of the case studies deal with municipal waste water technologies (MWWTT) and the rest with industrial waste water treatment technologies. Seven of the MWWTTs focus on tertiary treatment processes (i.e. sand filtration, ozonation, UV, wetlands and MembraneBioReactor) and five focus on nutrient removal (i.e. nitrification/denitrification, phosphorus removal with FeCl3). The remaining five studies on MWWTTs concentrate on sludge treatment technologies (i.e. incineration/land filling, agricultural land application, pyrolysis, anaerobic digestion, wet oxidation and supercritical water gasification). The five studies on industrial waste water focus on advanced oxidation processes (i.e. photocatalysis, photo-Fenton), membrane microfiltration, and one study on oil contaminated waste water analyses twenty different treatment processes.



Peter Augusto Hansen

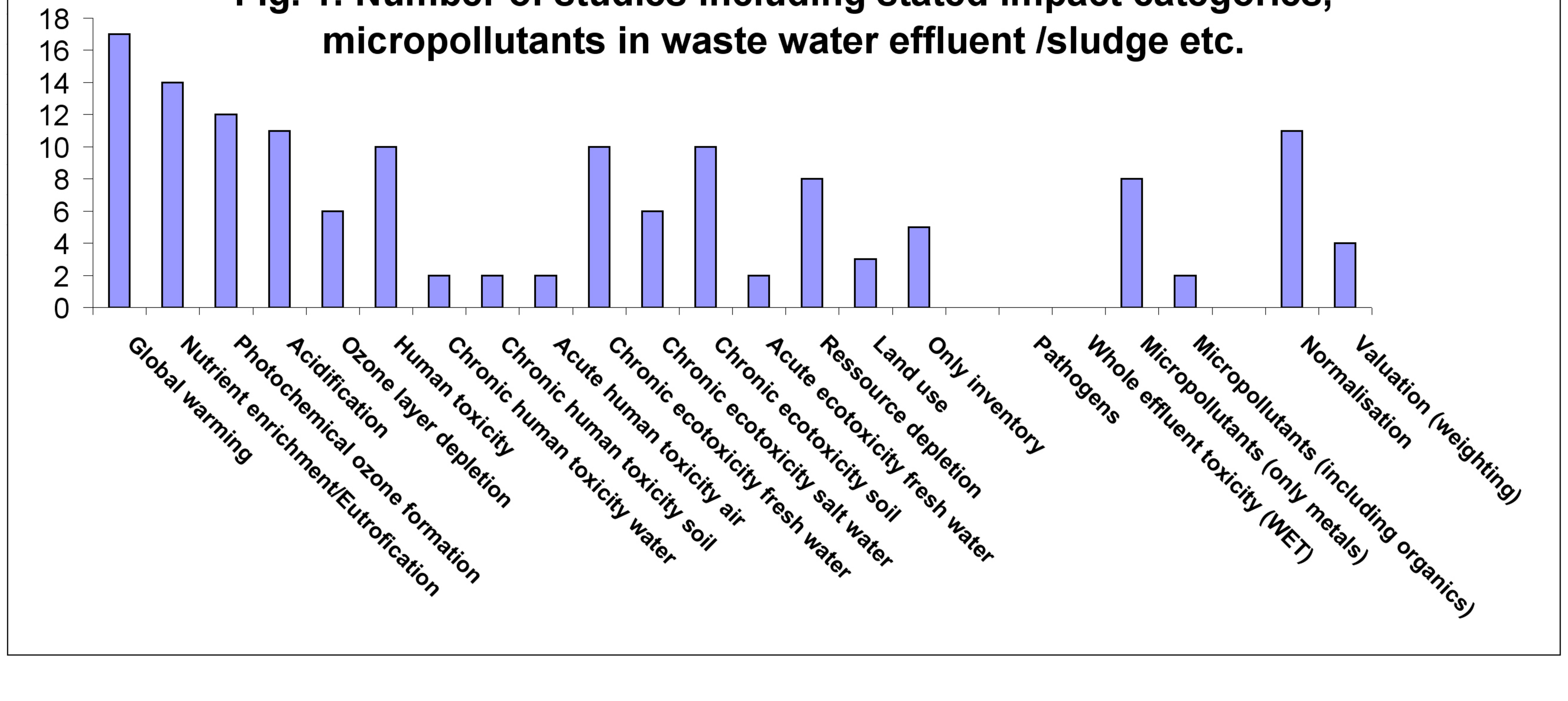
Problem shifting: solving a problem may create another somewhere else – LCA can help to avoid such sub-optimisation

Impact categories dealt with

The frequency of inclusion of the different impact categories is shown in Fig. 1. Not surprisingly global warming potential (17 studies out of 22) is dominating followed by the other energy-related impact categories. For the toxicity-related impact categories human toxicity is dominating (in total included in 12 studies), while ecotoxicity is included in ten studies. Besides stratospheric ozone depletion all included impact categories may show significant contribution to the impact profile of the waste water treatment technology depending on the actual type and case.

Potential impact of pathogens and evaluation of waste water effluent based on whole effluent testing (WET, ecotoxicity) is not included in any study. Potential toxic impact from metals in the effluent and/or sludge is included in eight studies but only specified in five (including Hg, Cd, Zn, Cr, Ni, Pb, and in one case As and Se). Specified organic micropollutants in the effluent is only included in one study i.e. LAS, DEHP and PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene). Also a few known endocrine disrupters are included in this study, viz. 17alpha-ethynylestradiol (EE2), 17beta-estradiol (E2) and nonyl phenol ethoxylate (NPE). Pharmaceuticals are not included in any study (except as precursor in a lab study on synthetic waste water) and pesticides only as a group in one study.

Fig. 1. Number of studies including stated impact categories, micropollutants in waste water effluent /sludge etc.



Importance of different life cycle stages

Material and construction stage: Although some authors argue for an exclusion of this stage based on former studies showing insignificant contribution, there are cases where a significant contribution from the material and construction stage is actually shown (e.g. wetlands, sand filtration, conventional treatment + microfiltration + ozonation). Anyway, in a more or less comprehensive way the material stage is included in about 85% of the studies and the construction stage in about 40%.

Use stage: Due to the use of electricity, fuels and the emission of pollutants from the waste water to air, with effluents and sludge, the use stage is found to be important in almost all studies.

Transport: Transport may or may not play a visible role, but typically not a dominating one. However, distance to place of application of sludge as fertilizer may be very important and a study on the case of a reedbed found transportation to contribute with 30% of the total energy consumption (transport of soil and more). Transport activities are included in about 70% of the reviewed studies.

Disposal stage: The importance of the disposal of resulting sludge is documented in several studies. Inclusion of the substitution of fertilizer production and of the potential toxic impact from especially the metal content of the sludge is found to be very important if the sludge is disposed on agricultural land. The decision to utilize the methane production from anaerobic digestion (substituting fossil energy) or to let it emit to air is also important.

References

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