

Life cycle assessment of the “anthropic water cycle” - Part 1 wastewater treatment plants

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Abstract

The final purpose of the whole study is to determine the environmental impacts arising from water production, water transport to the customer and wastewater treatment. This particular water cycle is called “anthropic water cycle”. In a first part, environmental impacts related to different systems used to clean wastewater are assessed. The focus is put on the main differences between a collective wastewater treatment plant and several small wastewater treatment plants for small rural community.

A first result of the study is the importance of sewer construction. This parameter has a great influence on the final result. A number of pollutants into water could not be integrated to the final result due to a lack of indicators in EI 99 and so, some work must still be done to have complete results. Further steps of the study will include water production, water transport to the customer and sludge management. Other wastewater treatment solutions would also be studied (individual wastewater treatment).

Goal and scope of the study

Goal of the study

The goal of the study consists to compare the environmental impact of wastewater treatment realised in a single centralised plant or in several smaller plants.

Function and Functional Unit

In this study, the function is wastewater treatment of a community of 11 000 inhabitants. The functional unit is 1 cubic metre of water.

Wastewater treatment plants

Centralised wastewater treatment plant

This centralised wastewater treatment plant is designed to receive wastewater of a population corresponding to 11 000 inhabitants. The life cycle of this plant includes construction and operation of the plant but also construction of the whole sewer network. This is an important parameter of the study. If the area covered by the wastewater treatment plant is large, the total length of the sewer network will increase considerably. Electricity and chemicals consumed during operation of the wastewater plant are taken into account. It is assumed that the wastewater treatment plant and the sewer are made of reinforced concrete.

Decentralised wastewater treatment plants

Several smaller decentralised wastewater treatment plants are placed. So, 11 000 inhabitants have their wastewater cleaned but the total length of the sewer network is less important compared to the centralised wastewater treatment plants. The system boundaries include construction and operation of the decentralised plants. This type of small plants do not use any chemicals during operation and therefore, only electricity consumption is taken into account for the plants operating step.

Figure 1 shows the boundaries of the regarded systems.

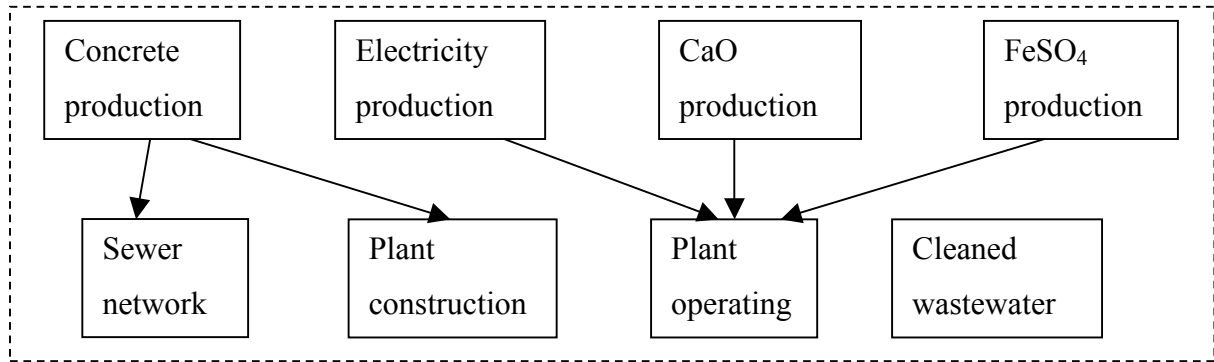


Figure 1 : System boundaries

Inventory analysis

This study is done with Eco-Indicator 99 on the basis of an inventory of a great number of pollutants. Main results of inventory obtained for major pollutants are shown in figures 2, 3, 4, 5, 6 and 7. These results are very characteristic of the study.

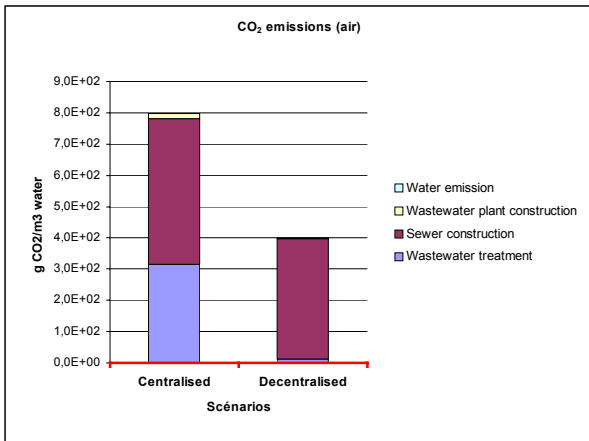


Fig. 2 – CO₂ emissions inventory

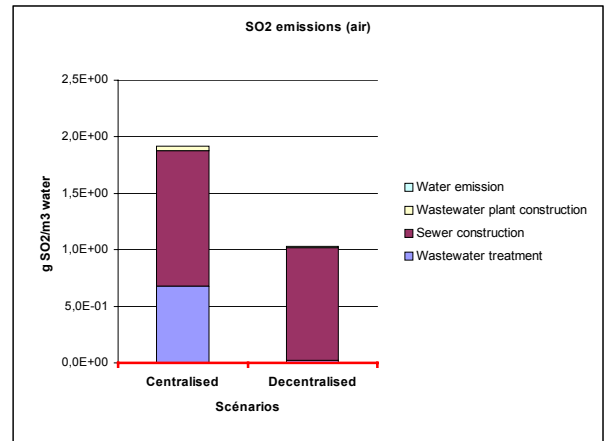


Fig. 3 – SO₂ emissions inventory

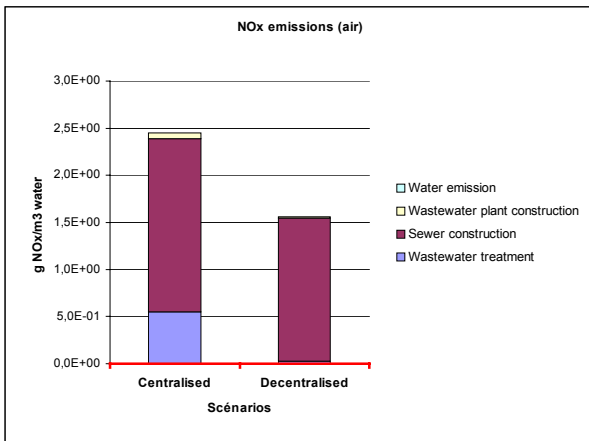


Fig. 4 – NO_x emissions inventory

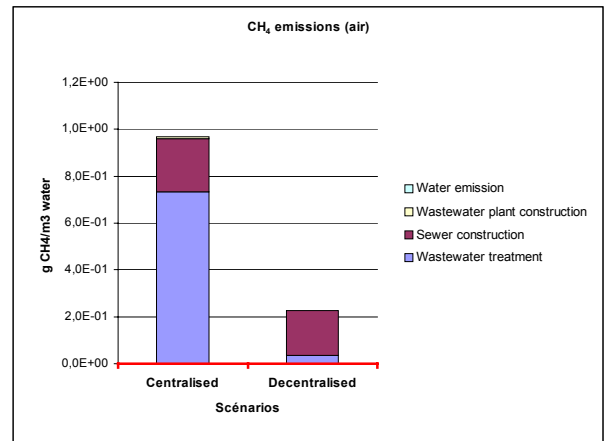


Fig. 5 – CH₄ emissions inventory

On figures 2, 3, 4 and 5, it must be noticed that sewer construction represents a great part of major atmospheric pollutants. For several decentralised wastewater treatment plants, sewer network is less extensive and therefore pollutants emissions are lower for this step. For centralised wastewater treatment plant, wastewater treatment itself is responsible for atmospheric emissions. This is mainly caused by production of chemicals which are not used in decentralised wastewater treatment plants. Wastewater treatment plant construction does not represent significant emission of major atmospheric pollutants.

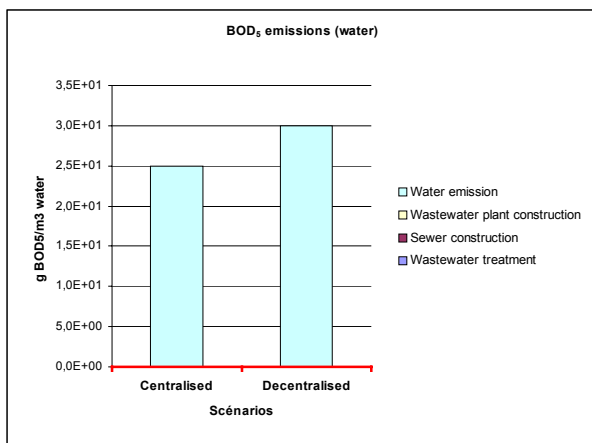


Fig. 6 – BOD₅ emissions inventory

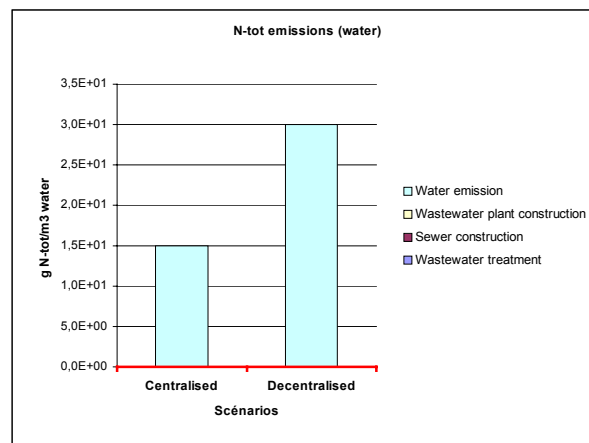


Fig. 7 – N-tot emissions inventory

Inventory of emissions of pollutants into water is very different. This fact is illustrated in figure 6 and 7. Wastewater treatment plant operating and installations (sewer and plant) constructing phases do not represent important emissions into water. Main emissions into water are caused by cleaned water after wastewater treatment. For this particular case, a single centralised plant has a better cleaning efficiency than several smaller plants. Unfortunately, a number of pollutants into water like BOD, COD and N-tot are actually not taken into account by EI 99. This is a problem that must be solved in a further part of the study.

Results

Figure 8 shows the global eco-score resulting of the comparison of centralised and decentralised wastewater treatment plants.

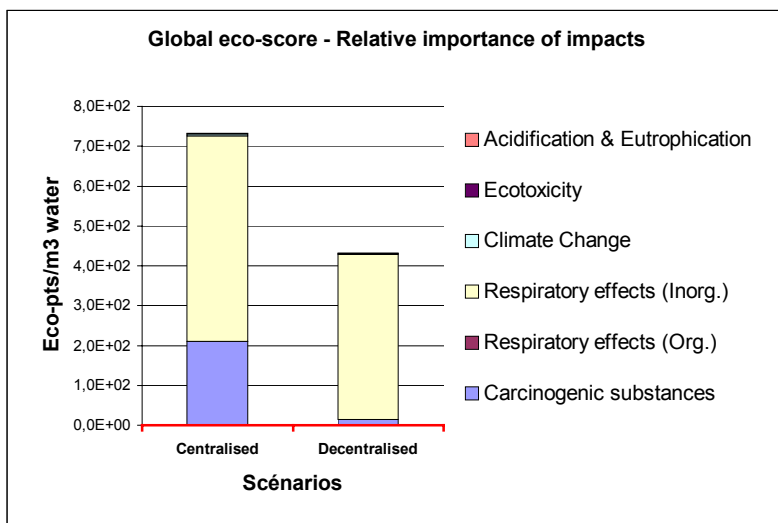


Fig. 8 – Global eco-score

From these results, it is easy to say that several decentralised wastewater treatment plants are a best solution from an environmental viewpoint. However, it has been noticed in the inventory that a number of pollutants could not be included in the final result. Emission of these pollutants seems to be relatively important especially in the case of the decentralised wastewater treatment plant. So, less good cleaning efficiency of small wastewater treatment plants is only partially taken into account in the final result. To achieve a good comparison, there is still an important methodological work to calculate damage factors for pollutants into water.

Conclusions

The first part of this study permit us to point :

- sewer network is an important parameter
- a lack of indicators for some pollutants into water
- interest of decentralised wastewater treatment plants (this fact must be confirmed in a further version of the study).

Further steps

These first results are the very beginning of a study of the whole “anthropic” cycle of water. In a further step, damage factors of pollutants into water like BOD, COD, etc will be searched or calculated. With these damage factors, it will be possible to complete this first study and to add different wastewater treatment solutions to the comparison. The study will also be extended to larger populations with official data. Life cycle of other chemicals (Ferric chloride, ...) used in wastewater treatment will also be explored.

Other parts of the whole study will include water extraction, drinking water treatment, water transport and sludge management. The final purpose of the study is to compare different water management scenarios.

References

Degremont (1998), *Mémento technique de l'eau*, Degremont.

Goedkoop M., Spriensma R. (1999), *The Eco-indicator 99 A damage oriented method for life cycle impact assessment. Methodology Report*, PRé Consultants, Amersfoort (NL).