# Synergetic Use of the Degrees of Freedom to Improve the Urban Waste Water System

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**Abstract** Due to increased demands on the urban wastewater systems (UWSs) and new legislation a major task is to look at how to upgrade existing urban waste water systems. This means that water managers have to scan all the different measures that can possibly be taken to improve the urban waste water system. To guide them in this process a concept has been developed in the context of the EU project CD4WC. This project aims at a cost-effective development of the urban waste water system for WFD compliance. The final goal is a set of tools, which will give guidance by analysing the system step by step and providing a possible combination of measures according to the specific circumstances and existing system lay-out that would give the best upgrading scenario. The whole project is subdivided in different workpackages. This contribution describes part of the first workpackage concerning the degrees of freedom (DOFs). A list of 85 DOFs based on a literature research and experience of the practice partners was compiled. The DOFs on this list were evaluated to come up with a restricted list of most important DOFs and those were described in detail. All DOFs are organised in a database and linked with case studies, model results, literature and queries can be made based on the characteristics of the DOFs.

## Options for the UWS to improve the receiving water quality

For the identification of the different degrees of freedom a list of 85 measures was compiled. This list was based on literature and experience of the practice partners involved in the project. To be able to focus on some measures such that the available time was not too much diluted, it was necessary to select the most important measures out of the list. Consequently the project group evaluated each DOF based on five criteria: compliance with new legislation; experience and acceptance; novelty; related costs (investment, operation, maintenance); what is the ease with which the measure can be implemented.

Twenty-eight degrees of freedom were selected (table 1). They are described in detail and linked to case studies and literature.

## Database

The final goal of the CD4WC project is a decision support aid (DSA). This DSA will lead the user through three steps:

1. the user will be informed about system analysis, key parameters, etc. and guided in data collection;
2. the user will be instructed how to identify drawbacks of the system and to set up feasible alternative system configurations;
3. the user will weigh different criteria and be guided while evaluating the different options.

This means that some options in the set of degrees of freedom have to be proposed based on the specific characteristics of the problem. So, to be practically useful, all possible DOFs (the extended list, 85 options) were organised in a database. In the database queries can be made based on the following system characteristics: subsystem, performance, maintenance and investment costs, implementation time, scale, impact on kind of pollution source, need of reconstructions.

## Interactions

For every degree of freedom the interactions with other options were considered, and positive or negative effects were described. This was needed to avoid that the expected outcome of a certain measure does not give the desired improvement in the receiving water quality because other factors are affected, e.g. the possible negative effect of disconnecting industrial water from the sewer system and optimisation of biological treatment systems. Due to the disconnection, the changed load composition to the wastewater treatment plant (lower COD) can influence the microbial community, and the advantage of smoothing the peak loads typical of a pure municipal system is lost. At the same time cost savings and better performance induced by the combinations of degrees of freedom could be quantified. An example is the combination of magnetic field applications together with chemical precipitation for small wastewater treatment plants.

## Conclusions

Investigation of all options available to a water manager/engineer to improve the receiving water showed that guidance to choose between them is needed. This guidance will be provided as an outcome of the CD4WC project. It will not only focus on one measure at a time but will also consider possible synergetic effects that make the combined measures more (cost-)effective. Some combined measures showed negative interactions and it is important to warn the water manager/engineer for this.

Table 1. List with important degrees of freedom for the urban wastewater system

| **Part of the system** | **DOF** |
|---|---|
| Catchment | Rain water infiltration: collection, buffering, reuse, filtering |
| | Toilet systems: dry toilets, composting toilets… |
| | Waste stream management: controlled discharge to sewer system e.g. Urine separation, black water separation, yellow water treatment, individual treatment of waste… |
| | Reduction of run-off |
| | Water reuse: bathing, washing, rainwater, toilet spilling |
| Sewer | Reduction of in-and exfiltration |
| | Methods of CSO storage/discharge/treatment **–** Combined sewer overflow reduction |
| | Separate vs. combined systems, disconnection industrial water |
| | Sediment management (e.g. Sand trap installation) |
| | RTC - storage capacity, discharge (Use of radar information for RTC) |
| | Optimise pumping strategy |
| | Retention tanks |
| WWTP | Optimisation of treatment processes (denitrification process, digestion process, mixing, aeration) |
| | Chemicals use |
| | Increase of the design flow, load increase |
| | RTC plants |
| | Control of RAS flow rate |
| | New processes (membrane technology) |
| Receiving water | Water plants, plants and trees on banks for natural bank reinforcement against erosion or for shading (flora) |
| | Structural measures / meandering /bottom structure |
| | Base flow variation |
| | Aeration |
| Whole system | Connection and extension of floodplains |
| | Integrated RTC |
| Economic instruments | Legal directives |
| | Charges or taxation |
| | Water pricing |
| | Tradable permits |