Matlab /Simulink Phenomenological Modelling Approach for Generation of Dynamic WWTP Influent Disturbance Scenarios

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Note that this short document does not by any means provide a complete description of how to use the influent generator but it may give some useful hints on the topic and avoid some unnecessary frustration. The document assumes that you are familiar with MatLab / Simulink and wastewater treatment process modelling and simulation. Also read the provided ASMXinfluentgenerator_agreement_DTULU.pdf

UNPACKING THE FILES

The files have been archived using .zip. Just unzip the files whatever your software you normally use for this purpose

FILE DESCRIPTION

When the files are unpacked you will find in the main directory (*ASMX_influentgenerator*) most of the files that are associated with the influent generator. In the subdirectory *Results* there is only an Excel document providing the correct results for the different implementation (ASM1, 2d and 3)

Three simulink model are available:

- *ASM1_Influentmodel.mdl* – simulate dynamic WWTP influent disturbance scenarios using ASM1 guidelines
- *ASM2d_Influentmodel.mdl* – simulate dynamic WWTP influent disturbance scenarios using ASM2d guidelines
- *ASM3_Influentmodel.mdl* – simulate dynamic WWTP influent disturbance scenarios using ASM3 guidelines

ASM1_influentmodel, ASM2d_Influentmodel and ASM3_Influentmodel are almost identical systems the initialization files have been pre-set different according to the different activated sludge guidelines. Moreover, ASM1 and 3 only considers organic carbon and nitrogen fluxes while ASM2d organic carbon, nitrogen and phosphorus fluxes. Finally, the influent fractionation, noise generation, first flush effect and the sewer system are based on different state variables

14 C-files are included in the distribution

- *asm1_fractionation.c, asm2d_fractionation.c and asm3_fractionation.c*- Three different influent fractionations based on the different state variables considered by the activated sludge models. In principle ASM1,2d and 3 considers different input fluxes and provides with different state variables
- *asm1_combiner, asm2d-combiner.c and asm3-combiner.c* – Add two separate streams into one based on load (the number of state variables change depending on the ASM)
- *firstflush_ASM1.c, firstflush_ASM2d.c and firstflush_ASM3.c* – Account for the "first flush"effect from the sewer network and re-suspension of the accumulated particulate material (the number of particulate state variables change depending on the selected ASM)
- *unisoilmodel.c* –describes storage of water in soil
- *sewer_asm1.c, sewer_asm1.c and sewer_asm3.c* – Three different sewer system models describing transport of flow rate, components and temperature (the number of state variable change depending on the selected ASM)

These files must be compiled on your local machine using the MatLab *mex* command before you can use the models (use the *mexall_ASMXinfluent.m* script).

In principle all the parameters and variables are defined in the different m files and the actual simulink blocks and the models therein never need to be adjusted (unless you want to rebuild the modelling approach to generate the different WWTP influent scenarios). Within simulink you only define parameters that are related to the numerical solver, storing of data and selecting which input data files should be used. The initialization m-files have associated with the model they influence: *ASM1_Influent_init.m, ASM2d_Influent_init.m* and *ASM3_Influent_init.m.* As long as you use the true BSM2 system parameters, you do not need to modify anything within the init files associated with the models. However, it is valuable to study the init files to see how the models are set-up.

18 input files are provided

- *day_HS.mat* – Represent the flow-rate daily profile from households.
- *CODsol_day_HS.mat, CODpart_day_HS.mat, SNH_day_HS.mat, TKN_day_HS.mat and PO4_day_HS.mat* – Represent the daily profiles for the different pollutants from households.
- *week_HS*.mat – Represent the flow rate weekly profile from households.
- *week_polHS.mat* – Represent the weekly variation. This pattern is applied to the different pollutants.
- *year_HS.mat* – Reprsent the yearly profile variation for households. This patter is applied to both flow-rate and pollutants.
- *week_IndS.mat* – Represent the flow-rate weekly profile from industry.
- *CODsol_week_IndS.mat, CODpart_week_IndS.mat, SNH_week_IndS.mat, TKN_week_IndS.mat and PO4_week_IndS.mat* – Represent the weeky profiles for the different pollutants from industry.
- *year_IndS.mat* – Represent the yearly profile variation for industry. This pattern is applied to both flow-rate and pollutants.

The number of input files changed depending on the ASM model selected (see **Table 1)**

Table 1. Input pollution loads for both HH and IndS depending on the ASM selected

ASM	HH	IndS
ASM1	CODsol_day_HS.mat, CODpart_day_HS.mat, SNH_day_HS.mat, TKN_day_HS.mat	CODsol_week_IndS.mat, CODpart_week_IndS.mat, SNH_week_IndS.mat, TKN_week_IndS.mat
ASM2d	CODsol_day_HS.mat, CODpart_day_HS.mat, SNH_day_HS.mat, PO4_day_HS.mat	CODsol_week_IndS.mat, CODpart_week_IndS.mat, SNH_week_IndS.mat, PO4_week_IndS.mat
ASM3	CODsol_day_HS.mat, CODpart_day_HS.mat, SNH_day_HS.mat,	CODsol_week_IndS.mat, CODpart_week_IndS.mat, SNH_week_IndS.mat,

The output variables are stored during simulations in the MatLab workspace. The number and the type of state variables change also according to the selected ASM model (see **Table 2**). The output time information s stored as a general individual variable in MatLab workspace called t (unit days). In principle all the different input and outputs to all the phenomenological models are stored during simulation. By default data are stored as a grab sample every 15 minutes. Note that dummy variables are set to zero just before the sewer system.

For the purpose to analyze the different evaluated influent three files exist.

- *Figure_ASM1_Influent.m*, *Figure-ASM2d_Influent.m*, *Figure_ASM3_Influent.m* – prints to the screen the different pollutant concentration and loads and plot the dynamic profiles of composite variables (COD, BOD5, TSS, TN and TP). It also give values or dispersion such as quartiles.
- *Smoothing_data.m* _ It is an exponential filter that facilitates the visualization of the results removing noise variations.

Naturally you can create any other helpful scripts for your specific purposes on your own.

RUNNING THE INFLUENT GENERATOR

When the archive has been unzipped you are ready to run the influent generator. A few simple instructions are given below to help you through the firs time and to test the system on your computer.

- Start MatLab and move to the *ASMX_influentgenerator*
- Command *mexall_ASMXinfluent.m* (if you have problems with your C-compiler you must solve this). Once successfully completed you need to re-mex all the C-files you have actually modified (which should normally not be done)
- Command *ASM1_Influentmodel*, *ASM2_Influentmodel* or *ASM3_Influentmodel3* depending on the type of influent you want create (the simulink window will appear)
- Command *ASM1_influentinit*, *ASM2d_influentinit*, *ASM3_influentinit* depending on the model you selected previously. This file will initiate all the variables and parameters, loads, data files…

Table 1. Output pollution loads depending on the ASM selected

	ASM1	ASM2d	ASM3
1	S_I (inert soluble material, gCODm^{-3})	S_{O2} (dissolved oxygen, g(-COD) m^{-3})	S_{O2} (dissolved oxygen, g(-COD) m^{-3})
2	S_S (readily biodegradable material, gCODm^{-3})	S_F (fermentable, readily biodegradable material, gCODm^{-3})	S_I (inert soluble material, gCODm^{-3})
3	X_I (inert particulate material, gCODm^{-3})	S_A (fermentation products, readily biodegradable material, gCODm^{-3})	S_S (readily biodegradable material, gCODm^{-3})
4	X_S (slowly biodegradable material, gCODm^{-3})	S_{NH4} (ammonia and ammonium, gN m^{-3})	S_{NH4} (ammonia and ammonium, gN m^{-3})
5	X_{BH} (heterotrophic biomass, gCODm^{-3})	S_{NO3} (nitrite and nitrate, gN m^{-3})	S_{N2} (nitrogen gas, gN m^{-3})
6	X_{BA} (autotrophic biomass, gCODm^{-3})	S_{PO4} (phosphate, gN m^{-3})	S_{NOX} (nitrite and nitrate, gN m^{-3})
7	X_{BA} (inert particulate from decay, gCODm^{-3})	S_I (inert soluble material, gCODm^{-3})	S_{ALK} (alkalinity)
8	S_O (dissolved oxygen, g(-COD) m^{-3})	S_{ALK} (alkalinity)	X_I (inert particulate material, gCODm^{-3})
9	S_{NO} (nitrite and nitrate, gN m^{-3})	S_{N2} (nitrogen gas, gN m^{-3})	X_S (slowly biodegradable material, gCODm^{-3})
10	S_{NH} (ammonia and ammonium, gN m^{-3})	X_I (inert particulate material, gCODm^{-3})	X_B (heterotrophic biomass, gCODm^{-3})
11	S_{ND} (soluble organic nitrogen, gN m^{-3})	X_S (slowly biodegradable material, gCODm^{-3})	X_{STO} (storage products, gCODm^{-3})
12	X_{ND} (particulate organic nitrogen, gN m^{-3})	X_H (heterotrophic biomass, gCODm^{-3})	X_A (autotrophic biomass, gCODm^{-3})
13	S_{ALK} (alkalinity)	X_{PAO} (polyphosphate accumating organisms, gCODm^{-3})	TSS (total suspended solids, gTSS m^{-3})
14	TSS (total suspended solids, gTSS m^{-3})	X_{PP} (polyphosphate, gPm^{-3})	Flow rate (m^3 day^{-1})
15	Flow rate (m^3 day^{-1})	X_{PHA} (poly-hydroxi- alkanoates, gCODm^{-3})	Temperature (^{0}C)
16	Temperature (^{0}C)	X_{AUT} (autotrophic biomass, gCODm^{-3})	
17		TSS (total suspended solids, gTSS m^{-3})	
18		X_{MeOH} (metal-hydroxides, , gTSS m^{-3})	
19		X_{MeP} (metal-phosphate, , gTSS m^{-3})	
20		Flow rate (m^3 day^{-1})	
21		Temperature (^{0}C)	

- In the simulink simulation menu select **start.** The system will simulate the system 728 days in time creating dynamic influent data. Output data will be stored every 15 minutes. The simulation will take around 5-10 minutes (depending on the computer)
- When the simulation is finished: command *Figure_ASM1_Influent*, *Figure_ASM2d_Influent or Figure_ASM3_Influen*t. From the 728 days of simulation only 609 will be taken. Next this script will calculate the effluent concentration and loads from day 245 to 609.It will also plot the dynamic profiles of some relevant variables
- The results should be more or less identical to the results shown in the excel file ASM_influents.

When you have reached this point you can be sure that the ASMX influent generator on your computer works properly.

FINAL COMMENTS

Try to understand the structure of the different m-files and c-files to grasp how to relate to each other. Run the different simulink files to create different influents according to the descriptions above to make sure that everything works. You should compare your results with the results provided in the Excel document. If your results are different then you are doing something wrong.

When you feel confident that you understand this implementation you may stat to create you own influent files for subsequent simulation studies. Remember, that this implementation is simply a starting point and a fully verified platform tor you to start working on you own.

Enjoy!