



## Waste water treatment plant analysis and simulation using computational tools: A review

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## Waste water treatment plant analysis and simulation using computational tools: A review

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**Abstract:** India is rich in water resources, which helps to achieve the country to meet most of the water requirements. Due to increased population, most of the water resources are getting depleted. Among the types of waste water generated according to source, there is a big gap in the treatment of domestic waste water. The proposed work present is planning to do a review about the modeling of waste water treatment plants with the help of different simulation softwares available in the industry and their advantages. Also it focuses on the role of simulation tools for a better understanding of the treatment process and major trends emerging in the field of wastewater treatment process

**Keywords:** Domestic waste water, simulation, software

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### Introduction

Water is one of the essential resources for stable life of living matters on earth. However due to the increased population and urbanization causes water resources depleted in a large amount. Due to the increased pollution to water bodies most of our water resources are disappearing and they reached to a state where they no

longer can be used, in order to save our water resources, polluted water need to be recovered and retreated. Here Waste water treatment plants come in to play, which helps to attain depleted water resources in to good quality water. Corresponding to the type of wastewater generated the treatment needs for water changes considerably.

In India recent reports by central pollution control board of india<sup>1</sup> says that out of the total waste water generated about 74% of domestic water is discharged in to the environment as untreated. In order to minimize the untreated water discharge from domestic areas, waste water need to be treated at the point of discharge. Proper and scientific methods of treatment would help to eliminate the problems associated with improper discharge of polluted water to safe drinking sources in many parts of our country.

Nowadays for the design, control, predict system behavior and all, modeling using computer simulations are increasingly used. Different Modeling software packages such as SSSP, STOAT, AQUASIM, EFOR, GPS-x and WEST are available on the market<sup>4</sup>. The quality of simulation studies can vary strongly depending on the goal set, expertise available and resources spent. Different approaches and insufficient documentation make the quality assessment and comparability of these studies difficult or almost impossible. To overcome these obstacles a general guideline for the implementation of a simulation study is needed. This would help to remove the current barriers to the treatment models.

### **Introduction to the basic models in industry**

Activated sludge systems –ASS makes the most of the waste water treatment plants –WWTP all over the world with versatility in the process. The activated sludge process is one of the major biological wastewater treatment methods which are used widely for wastewater treatment.

Several studies studies<sup>2,4,7</sup> talk about different activated sludge models currently available in industry. In which the first model ASM1 was established in 1987 by IAWQ-International Association Water Quality. ASM1- Activated Sludge Model No.1 is a basic model which comprises of stoichiometric and kinetic expressions that describe the biochemical transformations of soluble and particulate compounds in the activated sludge, that is, the processes of carbonaceous oxidation, nitrification and denitrification. After the first model several models with modifications to the process were arised. ASM2 – Activated Sludge Model No.2, which includes the biological phosphorus removal and also the processes for phosphorus precipitation<sup>2</sup>.after that ASM3 were raised in 1998. Which provide a new platform for modeling with certain corrections to the ASM1 model. The ASM3 model assumes that all the readily biodegradable COD is first

taken up and stored intracellularly<sup>7</sup>, prior to biomass growth. Second advantage of ASM3 is that it is easy to calibrate when compared to ASM1<sup>1</sup>. The models of the ASM family are considered state-of-the-art models of activated sludge processes which are used in most of the modeling and simulation studies. After that several models were raised with significant modifications such as mantis model by Hydromantis, Bench mark simulation model etc.

## **Waste water treatment using software**

A WWTP simulator environment can be described as software that allows the modeller to simulate a waste water treatment plant - WWTP configuration<sup>12</sup>. The major software currently used in industry are GPS-X, STOAT, BIOWIN etc among these, GPS X is the commercially trending one .In which the user-friendly drag and drop options and comprehensive database of unit processes allows users to quickly assemble a treatment plant model, enter characterization data, and run simulations. And the output to the simulations can be viewed and stored in a systematic way. Studies were conducted using GPS-X software for modification of existing process in order to improve the efficiency of the

current plants. A study by Sofia Filipe<sup>1</sup> conducted in Portcel at an industrial complex. In which the existing plant is modeled using a new scenario for improving efficiency using GPS-X, which shows that process modifications and model calibration can be easily done using this software. Another study by Mervat<sup>3</sup> and his colleges at the university of Balamand using GPS-X suggests that this software can be used to improves the capacity , operating efficiency and for optimizing the existing facility. Also a case study from Kurdistan Iraq by Hayder M<sup>8</sup> and his colleges used STOAT software their main objective was to redesign and simulate the existing plant by adding secondary treatment facilities to the existing plant. Optimization studies were conducted using dynamic simulation in order to improve the plant performance. Wende Tian<sup>5</sup> and his colleges conducted a study using MATLAB in an organic rich waste water, in their study both experimental and simulation study were conducted using an extraction column. simulation is carried out using UNIFAC method and the results suggests that efficient extraction column can reduce the organic content in waste water considerably and the dynamic simulation regarding the same were carried out. A study by Mare Andre<sup>7</sup> and his colleges using GPS-X where

conducted, which review about plant optimization using the software also it reviews about the role of dynamic model in plant capacity performance, in their studies what if scenarios were analyzed with the help of dynamic models. They suggests that due to increased cost such as both operating and energy costs ,several upgrades are needed for the existing facility in order to meet the constraints which are analyzed and calibrated using GPS – Xin their study. A study by Saziye<sup>10</sup> using MATLAB was conducted to find the optimum design parameters for activated sludge process for an existing facility. Modeling equations regarding different constraints were constructed and it is analyzed and solved using fmincon computing tool in MATLAB. Most of the studies using computer software focus on modeling the existing facility or improving the capacity or other relevant parameters for upgrading the waste water treatment facility. However there are several studies available which mainly focuses on experimental works and validating those works with computer simulation tools. A work by W E Elshorbagy<sup>11</sup> at United Arab Emirates concludes an experimental analysis by respirometry, lab controlled methods followed by validation and comparison of obtained data by simulation. They suggest that a well calibrated ASM model is an identification of the

stochiomertic and kinetic parameters. Which help to in good representation of the process biochemical behavior. Depending up on the software used and the analysis requirement the outcome of the study varies considerably.

### **Advantages using simulation tools**

Models are representations of the knowledge we have about a system. If we can prepare models that are accurate representations of real systems, then we can use them to conduct experiments which otherwise could not be possible<sup>7</sup>. Dynamic modelling using a well-calibrated model can: Accurately size unit processes and select the best design alternatives, which will help to save process design time. And also help to validate and achieve confidence in design. It will help to evaluate multiple optimization scenarios to minimize operational costs, such as energy costs, while meeting effluent quality requirements. They will help to investigate process changes that are required to controlled or avoided in order to achieve nutrient removal in proper way. An accurate model will help to predict the effects of taking one unit processes off-line for maintenance. And also which will help to accurately measure process control

improvements needed to the existing facility. Also help to train plant operators by illustrating the effect of operating decisions on plant performance.

### **Future of water treatment technologies**

The wastewater industry is currently facing dramatic changes, shifting away from energy-intensive wastewater treatment towards low-energy, sustainable technologies capable of achieving energy positive operation and resource recovery. The latter will shift the focus of the wastewater industry to how one could manage and extract resources from the wastewater, as opposed to the conventional method of treatment<sup>9</sup>

### **Conclusions**

Nowadays Activated sludge modeling and simulation are widely applied in waste water treatment facilities .which helps in Learning, design and process optimization of WWTP in a better way.

Dynamic simulation of wastewater treatment plants (WWTPs) is generally used as a powerful tool to increase the detailed knowledge on the process and system behavior, for optimisation studies which includes performance evaluation, operational optimisation, controller design, and

conceptual process design, for model-based process control. It can be seen that dynamic simulation becoming an important tool for the scientific community by providing its usefulness in the general wastewater treatment practice.

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