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EXPLORING THE EFFICIENT TREATMENT OF PETROCHEMICAL WASTE WATER USING ADVANCED SIMULATION SOFTWARE FOR WASTE WATER PLANT

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Abstract: For the purpose of a petrochemical facility located at Indorama Eleme Petrochemical, Nigeria, a dynamic simulation framework was designed, calibrated, and validated. The mathematical model was validated and calibrated based on plant monitoring results that spanned a period of three years. As a result, the model achieved an accuracy of 11.7 mg/L for effluent chemical oxygen demand (COD), 0.52 mg/L for the concentration of ammoniacal nitrogen (NH3-N), and 3.27 mg/L for the total amount of suspended solids (ASS), respectively. Since then, the simulation model has been put to use for troubleshooting throughout operational upsets, planning plant transformations, and developing possibilities for improvement. In this case study, the simulation model was utilized to help in troubleshooting and rectification of a plant upset caused by the entrance of a surfactant compound, which resulted in excessive effluent TSS and COD levels. During the resulting troubleshooting actions, the model was effectively utilized, and it gave crucial insights that supported the plant operators in promptly responding and restoring the equipment to a normal functioning state.

I. INTRODUCTION

The nature of the wastewaters produced by petrochemical facilities is complicated, and the features of these wastewaters are unique to each individual petrochemical product that is being created in the facility. Prior to being released into the environment, petrochemical effluents often need to undergo treatment that is based on processes that are physical, chemical, and biological in nature. This is done to ensure that water bodies are not polluted and to comply with rules designed to safeguard the environment.

Users are able to build wastewater plant flow schemes, which simulate the performance of the plant at certain operating and influent loading circumstances thanks to a variety of different wastewater treatment plant simulation software packages that are available for purchase on the market today. These simulator software packages provide mathematical models that represent the unit processes. Some examples of these processes are the activated sludge system, chemical precipitation, clarifying, and sludge handling. The systems are commonly stated graphically through the use of an icon-based technique; once the user has defined the graphical flow scheme and influent parameters, the simulation may be conducted to obtain results [1].

A petrochemical plant in ELEME, Nigeria is fitted with an Integrated Effluent Treatment System (IETS) for the purpose of treatment of effluents generated by the facility. The goal of this treatment is to reduce the pollutant concentrations in the effluents to levels that are in compliance with the Nigerian wastewater discharge requirements. Plant upsets have been known to occur at this facility in the past as a result of unplanned or accidental discharges of hazardous or high-strength effluent into the IETS. These occurrences triggered problems with operation including a shutdown of the plant in an endeavour to guarantee that the quality of the final effluent discharge does not exceed the permitted limitations. The IETS was created with the intention of treating wastewater from many plants at a rate of up to 500 m3 /h. It is made up of a number of sub-systems:

- The primary treatment consists of an equalisation tank and a diversion tank.
- Tertiary Treatment - Lamella Clarifiers
- Secondary Treatment - Aeration and Deaeration Basins
- Sludge Management System - Thickener, Sludge Digester, Belt Press, Land Farm
- Check Basin, and Recycle Basin.

The processing plant also has a second collecting header that is meant to collect wastewater that does not meet the specifications, and this effluent is then sent to the Diversion Tank.

Using a wastewater treatment facility's simulator that is available for purchase, a simulation model was developed for the IETS. The goals of this model were to: assist in investigating strategies for handling increased loads; predict IETS performance during abnormal conditions; assist in investigating options to optimize chemical and energy costs; assist in generating options that enhance treatability; and provide an interactive platform for the training of operators. Using data from plant monitoring collected over a period of three years, the model was established and verified. Since then, the concept has seen a significant amount of use for the aforementioned goals.

This article presents both the approach and the results of the construction of the simulation model for the wastewater treatment plant. According to the findings of the model validation, the calibrated model's prediction was reasonably accurate. The root means square deviation (RMSD) for the effluent chemical oxygen demand (COD), the concentration of ammoniacal nitrogen (NH 3-N), and the amount of total suspended solids (TSS) was calculated to be 11.7 mg/L, 0.52 mg/L, and 3.27 mg/L, respectively, for normal operating conditions.

We give a case study on the use of the validated model to the goal of aiding in the debugging of a plant upset occurrence involving the entrance of surfactant chemical. It is well knowledge that the introduction of surfactant into an activated sludge process will result in operational difficulties. According to some reports, the inhibitory limit of lubricants for the activated sludge process is somewhere in the region of 100-200 mg/L [2]. The mechanism that causes the disruption of the activated sludge process is due to the breaking of loosely bonded flocs and, as the percentage of the surfactant increases, firmly bound flocs. This results in poor settling of the sludge blanket and suspended solids carryover. In the end, lysis of microbial cells will occur when significant quantities are present [3]. During the surfactant ingress incident that occurred at the facility, the validated simulation model was utilized to quickly gain an understanding of the likelihood of effluent toxicity, estimate the percentage of surfactant that was still present in the aeration tank, and predict the likely process behavior in the days following the incident. The operators of the facility utilized this information in order to make decisions on the course of action that would most expeditiously return the manufacturing facility to regular conditions of operation.

II. AIMS AND OBJECTIVES

The improvement of the overall efficiency and efficacy of the process of treating petrochemical wastewater is the goal of the investigation into more effective methods of treating petrochemical wastewater utilizing cutting-edge simulation software designed for use in wastewater treatment facilities. This entails modeling and analyzing the behavior of the wastewater treatment plant using state-of-the-art simulation software, which enables engineers and operators to optimize a variety of parameters and procedures.

THE SPECIFIC OBJECTIVES OF THIS TOPIC INCLUDE:

- Understanding the composition, properties, and issues involved with treating petrochemical wastewater: The first goal is to get a full understanding of the composition, properties, and challenges connected with treating petrochemical wastewater. Analyzing the presence of different pollutants and contaminants, such as hydrocarbons and heavy metals, is part of this process.
- Using sophisticated simulation software: The next goal is to construct accurate and realistic models of the wastewater treatment facility using advanced simulation software. This program enables engineers to simulate numerous situations and assess the effects of alternative treatment procedures on the plant's overall efficiency and effectiveness.
- Optimizing treatment processes: The goal is to identify and optimize the primary treatment processes involved in treating petrochemical effluent using simulation software. This may entail comparing several approaches, such as

biological treatment, chemical precipitation, and advanced oxidation, to establish the most effective combination for successful pollutant removal.

- Improving resource utilization: Another goal is to maximize the use of resources in the treatment facility, such as electricity, chemicals, and water. Simulation software can assist in identifying areas where resource consumption can be reduced without sacrificing treatment quality, resulting in cost savings and environmental advantages.
- Environmental impact assessment: The ultimate goal is to analyze and reduce the environmental effect of petrochemical wastewater treatment. This involves evaluating effluent quality, assuring compliance with regulatory standards, and adopting initiatives to reduce dangerous material discharge into the environment.

The effective treatment of petrochemical wastewater using modern simulation software can help to sustainable and environmentally friendly practices in the petrochemical sector by researching and accomplishing these targets and objectives.

III. METHODOLOGY

a. Mathematical Development Model

i.Data collecting and analysis

We gathered all of the necessary data and information pertaining to the design and operation of the IETS, such as process flow diagrams (PFDs), piping and instrumentation diagrams (P&IDs), design data and calculations, material balance, daily operational monitoring data, previous characterisation reports, process descriptions, and operating philosophies. In addition, an investigation into the characteristics of the wastewater was commissioned in order to collect the data necessary for activated sludge modeling, such as the percentages of COD and nitrogen that are biodegradable and inert respectively. A further test, known as a bio-assay, was carried out in order to ascertain the component of the wastewater known as easily biodegradable COD (rbCOD).

In some instances, essential model input parameters weren't measured as part of the routine plant monitoring data. This was an issue in a number of instances. Therefore, ratios of these parameters to other accessible parameters were computed during the times that data in question were available (for example, during characterisation research), and the findings were generalized such that the parameter that was unidentified could be determined for other time periods.

For instance, the ratio of chemical oxygen demand (COD) to organic nitrogen was computed whenever data on total nitrogen was accessible. This ratio was then applied to the computation of total Kjeldahl nitrogen (TKN). In addition, standard deviations of COD fractions were gleaned from the available research and included into the process of finalizing the coefficient of determination (COD) fractional statistics.

ii.Model Layout Design

Following data collection, a model architecture was created to mirror the current facility as nearly as feasible in terms of flow configuration, influent characteristics and behavior, operational circumstances, and equipment requirements. Processing stream state variables as well as composite variables, and stoichiometric ratios were also defined using design or operational data. The model layout and model flow linkages were developed using PFDs.

iii.Calibration and Validation of Models

The standard deviations of the flow and composition parameters, as well as the mass balance, were calculated using plant monitoring and characterization data. After that, the model was calibrated to match the average composition data by running it repeatedly and modifying the parameters that defined the model. Figure 1 depicts the method of operation.

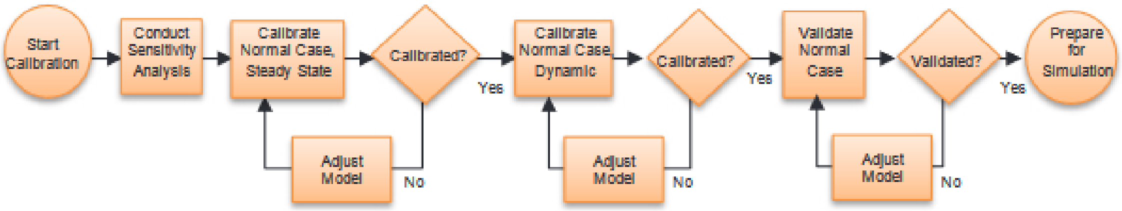


Fig. 1. Work Process Methodology for Calibration and Validation

The model's accuracy was determined as the best match possible to the majority of specified parameters, as shown below:

- Avg. NH_3-N at clarifier overflow
- Avg. COD at clarifier overflow
- Avg. TSS at clarifier overflow
- Avg. mixed liquid suspended solids (MLSS) in Aeration Tanks

A sensitivity study was performed by altering the model input parameters and analyzing the effect on the model output parameters (such as COD, NH_3-N, TSS, nitrite and nitrate nitrogen (NO_2-N/NO_3-N), and MLSS). This was done to help with the calibration work that was being done.

All of the biological stoichiometric and kinetic parameters, in addition to some of the influent characterization parameters, were subjected to the sensitivity analysis procedure. Following the sensitivity analysis, the model was calibrated using the average or mean values of the obtained data. This was done after the sensitivity study was completed. The mathematical model was then calibrated utilizing a set of dynamic, time-series data after the steady-state calibration values were used as an initial point in the process. In most cases, the performance monitoring information contained inside a single set of dynamic or time series data spans a period of three months. Following the model's validation using various data sets during typical plant operating circumstances, the recalibration of the model utilizing dynamic data was completed. The sum of the absolute RMSD values between the model and the data were determined for COD, NH_3-N, and TSS in the clarifier overflow effluent. This was done in order to assess how well the model fit the data.

IV. AN INVESTIGATION INTO A CASE STUDY

a. Context of the occurrence

In September of 2013, there was an incident in which operators observed white foam that looked like billowing clouds on the surface of the IETS aeration tanks. Additionally, the water quality findings of the effluent from the clarifier overflow indicated increased levels of total suspended solids (greater than 50 mg/L) and chemical oxygen demand (greater than 250 mg/L). Additionally, it was seen that the effluent was cloudy. As a consequence of this, the operators of the plant came to the conclusion that the best course of action would be to momentarily accumulate the wastewater in the Equalization tank while also temporarily redirecting the waste water to the Recycle Basin for storage. Additionally, they chose to limit the flow of influent to the IETS to half of the entire incoming the rate of flow. In the interim, personnel at the factory endeavoured to identify the source of the problem and find a solution to it. It was hypothesized that the feed for the IETS had been contaminated with an effluent stream that had a high concentration of surfactant.

b. The procedures for the investigation

To aid in the investigation of the incident, the IETS model was run with the most recent plant data from monitoring systems to identify the categories that follow:

- Perhaps the chemical infiltration was interfering with the process of COD biological oxidation.
- Calculate the expected quantity or concentration of surfactant remaining in the system.
- Simulate the possible outcomes of intervention efforts.
- Simulate the anticipated time to normalcy after performing intervention steps.

It is likely that the high COD was the consequence of inadequate clarity at the secondary clarifiers, which contributed to an increase in particle COD, given the physical observation of white billowy foam and the possible entry of a high concentration of surfactant. The model was run by modifying the settling parameters inside the IETS model in order to achieve model effluent TSS levels that closely match the actual plant monitoring data. This was done in order to verify that this is the case.

The clarification factor, which is a relative clarity index that ranges from 0 to 1 and describes the sedimentation characteristics of the secondary clarifier, was changed in the model through a process of trial and error in order to acquire a fit to the plant effluent TSS data. This was done in order to obtain the optimal fit to the data. When a good fit is established for TSS, the model output for COD is compared to the actual effluent COD; if a good match is obtained, it is possible to infer that the higher COD is due to the increased particle COD from the poor clarification (i.e. there are no hazardous consequences). If a good fit is not obtained, it is possible to conclude that the elevated COD is not due to the increased particulate COD from the poor clarification. On the other hand, if a good match is not seen (that is, if the real COD is higher than the model prediction), this suggests that there is some impairment in the COD's biological oxidation.

It was determined to be difficult and impractical to attempt to measure the concentration of the surfactant that was present in the system. Because of this, the simulator of the wastewater treatment plant was used to predict the expected proportion of surfactant still present in the system as well as the amount of time necessary to reduce the amount of surfactant present. In order to do this, a model was built that included a straightforward tank (one that does not involve any reactions) that possessed the identical volume and retention duration as the aeration tank and the clarifier system. To simulate the amount of surfactant that will be injected into the system, a "dummy" chemical was put into the influent. The fake substance was put into the system in the form of a pulse feed in order to simulate the actual working conditions, which consisted of the offending stream being cut off as soon as the incident was noticed. The actual concentration of the surfactant was not measured; nevertheless, in the model, the starting concentration of the dummy chemical in the aeration tank was determined to be 100 mg/L such that it would reflect 100% of the initial concentration of the surfactant. The simulation employed the real flow profile of the influent stream that was collected from the plant's distributed control system history data. The resultant dummy compound concentration profile was produced using the model. In addition, a predicted feed flow profile for the subsequent two months was taken into consideration in order to establish the surfactant concentration after the initial high dosage.

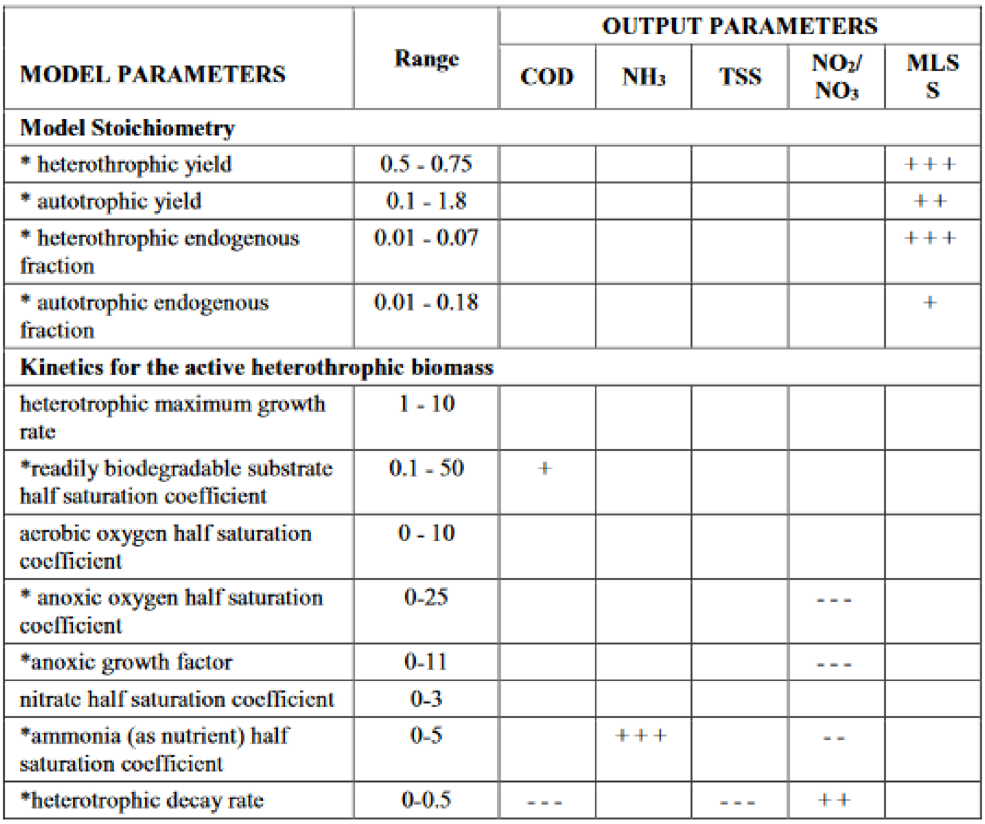
The precise anticipated feed flow profile, in addition to the feed concentration profile (total COD, NH 3-N, NO 3-N, and TKN), was entered into the entire IETS program and simulated to evaluate the effluent quality resulting from the clarifier result, incorporating COD, TSS, and NH 3-N.

V. RESULTS AND DISCUSSION

a. Results of model calibration and validation

Table 1 displays the findings of the sensitivity analysis. The sensitivity analysis reveals that the mathematical model's stoichiometric parameters only appear to affect the biomass (i.e. MLSS) and have no effect on the other output parameters. Except for the MLSS, the momentum parameters influence all wastewater parameters. The influent parameters, which directly contribute to mass loading and composition, have the largest influence on every one of the output values for the parameters.

Table 1. Results of model sensitivity analysis



MODEL PARAMETERS	Range	OUTPUT PARAMETERS				
		COD	NH_3	TSS	NO_2/ NO_3	MLSS
Model Stoichiometry						
* heterothrophic yield	0.5 - 0.75					+ + +
* autotrophic yield	0.1 - 1.8					+ +
* heterothrophic endogenous fraction	0.01 - 0.07					+ + +
* autotrophic endogenous fraction	0.01 - 0.18					+
Kinetics for the active heterothrophic biomass						
heterotrophic maximum growth rate	1 - 10					
*readily biodegradable substrate half saturation coefficient	0.1 - 50	+				
aerobic oxygen half saturation coefficient	0 - 10					
* anoxic oxygen half saturation coefficient	0-25				- - -	
*anoxic growth factor	0-11				- - -	
nitrate half saturation coefficient	0-3					
*ammonia (as nutrient) half saturation coefficient	0-5		+ + +		- -	
*heterotrophic decay rate	0-0.5	- - -		- - -	+ +	

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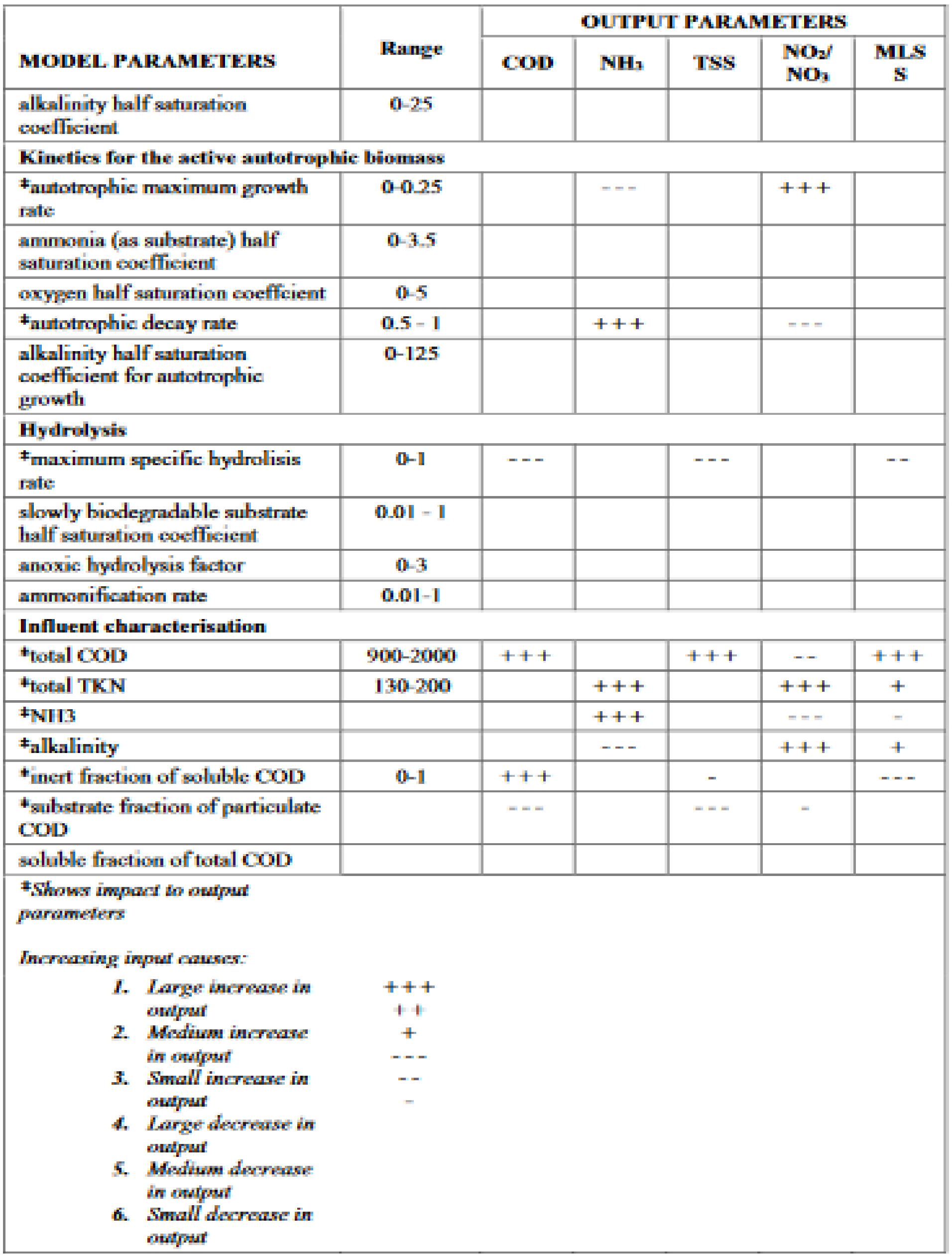

MODEL PARAMETERS	**Range**	**OUTPUT PARAMETERS**				
		COD	**NH_3**	**TSS**	**NO_2/ NO_3**	**MLSS**
alkalinity half saturation coefficient	0-25					
Kinetics for the active autotrophic biomass						
*autotrophic maximum growth rate	0-0.25		- - -		+ + +	
ammonia (as substrate) half saturation coefficient	0-3.5					
oxygen half saturation coeffcient	0-5					
*autotrophic decay rate	0.5 - 1		+ + +		- - -	
alkalinity half saturation coefficient for autotrophic growth	0-125					
Hydrolysis						
*maximum specific hydrolisis rate	0-1	- - -		- - -		- -
slowly biodegradable substrate half saturation coefficient	0.01 - 1					
anoxic hydrolysis factor	0-3					
ammonification rate	0.01-1					
Influent characterisation						
*total COD	900-2000	+ + +		+ + +	- -	+ + +
*total TKN	130-200		+ + +		+ + +	+
*NH3			+ + +		- - -	-
*alkalinity			- - -		+ + +	+
*inert fraction of soluble COD	0-1	+ + +		-		- - -
*substrate fraction of particulate COD		- - -		- - -	-	
soluble fraction of total COD						

**Shows impact to output parameters*

Increasing input causes:

1. *Large increase in output* + + +
2. *Medium increase in output* + +
3. *Small increase in output* +
4. *Large decrease in output* - - -
5. *Medium decrease in output* - -
6. *Small decrease in output* -

An acceptable model was established for the steady-state circumstances of normal operation by utilizing the Sensitivity Analysis matrix, which may be seen in Table 1. The ensuing dynamic modeling, which included additional model refining, made use of the calibration set as a starting point for the process. We used a data collection consisting of daily plant data spanning four months in order to perform dynamic calibration for normal operating circumstances. In order to achieve a reasonable fit to the dynamic data set, the following model parameters were modified during the dynamic calibration process:

- Yield from heterotrophic growth
- Endogenous portion of the heterotrophic type
- Yield from autotrophic processes
- Autotrophic spontaneous fraction
- Half-saturation coefficient of an easily biodegradable substrate
- Half-saturation coefficient of anoxic oxygen
- Nitrate half saturation coefficient
- The anoxic growth factors
- A value for the half saturation coefficient of ammonia (as a nutrient)

After the model had been calibrated, it was verified using several data sets, each of which spanned a period of three to four months. Table 2 presents the results of RMSD calculations performed during regular operations. According to the findings, the average accuracy of the model's predictions for COD, NH 3-N, and TSS is 11.7 mg/L, 0.52 mg/L, as well as 3.27 mg/L, respectfully.

Figure 2 presents an analysis of the results of the model and the real plant monitoring data for Dataset 2 (Table 2), demonstrating that there is a good agreement between the findings of the model and actual data throughout the time period of the simulation.

Table 2. Root Mean Square Difference (RMSD) of model vs actual data, in mg/L

Parameter	Dataset 1 (3-month span)	Dataset 2 (3-month span)	Dataset 3 (4-month span)	Average
COD	10.4	14.0	10.8	11.7
NH3	1.43	0.08	0.05	0.52
TSS	4.72	2.97	2.12	3.27

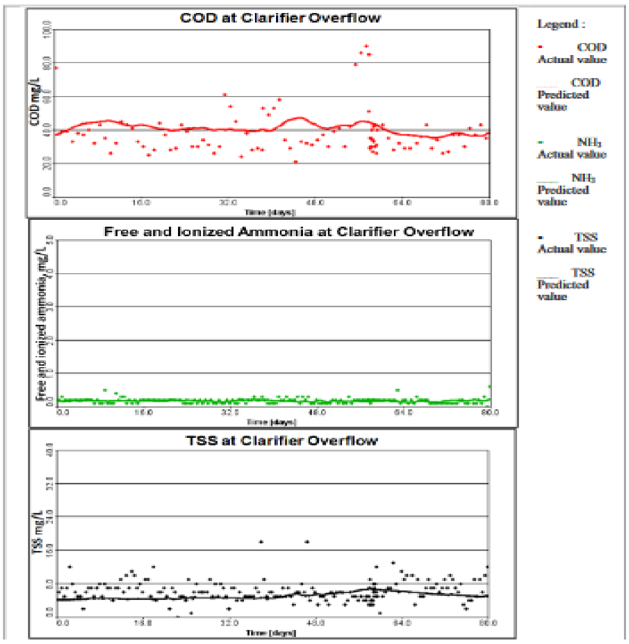

Fig 2: Model prediction of COD, NH3-N and TSS compared to actual plant data for validation

b. Case study analysis

Figure 3 displays the model-predicted with real TSS results during clarifier overrun. It is possible to acquire a good match for the TSS at the clarifier overflow by modifying the clarifying factor. This is an illustration of the bad settling circumstances that developed during the surfactant infiltration event.

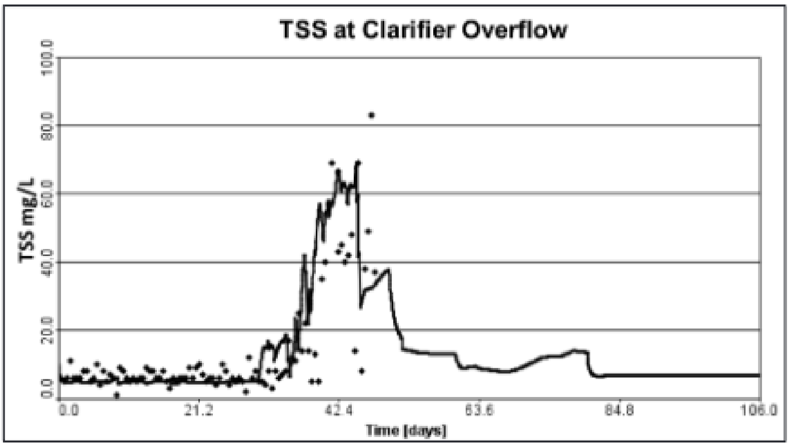

Fig 3: Model prediction and actual results of TSS at clarifier overflow during surfactant ingress event

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Both Figures 4 and 5 depict the incident's wastewater influent flow and features of the influent.

In the model, the surfactant infiltration happened around day 40. Up to day 47, real-life data was utilized; beyond that, planned flow and composition data were included into the model. The statistics show that, as part of the operational reaction to the event, the feed flowrate was significantly lowered following the incident, from about 100 m3 /h to 20 m3/h.

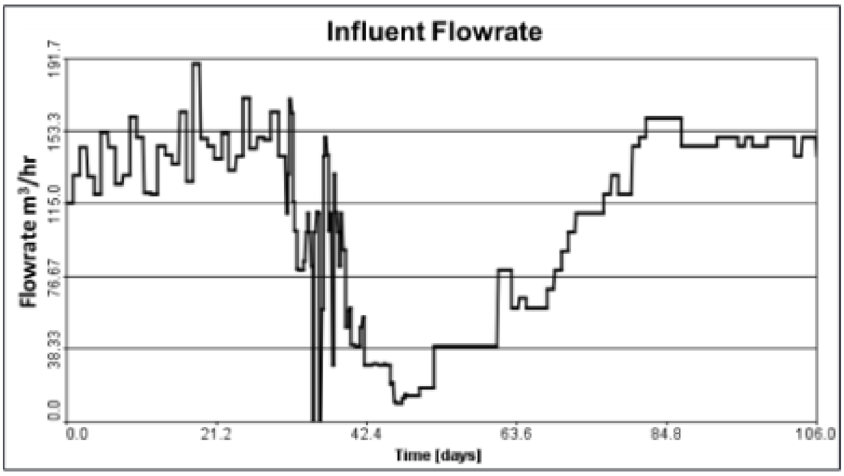

Fig 4: Influent feed flowrate of the IETS during surfactant ingress event

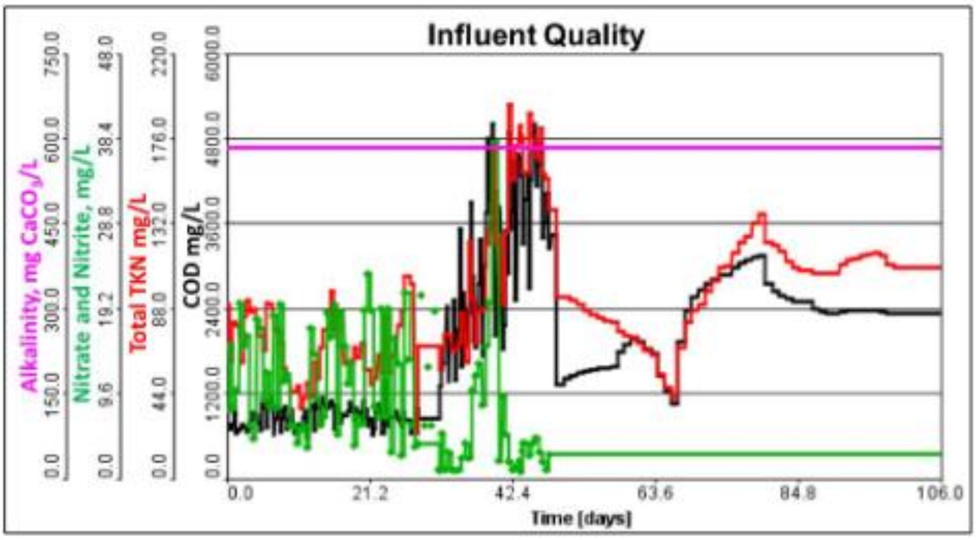

Fig 5: Concentration profiles of COD, TKN, nitrate/nitrite and alkalinity in the IETS influent during surfactant ingress event

Nevertheless, the analysis also reveals that roughly three weeks before the surfactant ingress, the influent COD had started to progressively increase from 1000 mg/l to 4800 mg/l. This increase occurred before the surfactant ingress.

Figure 6 presents a comparison of the model forecast with the actual COD measurements measured at the clarifier overflow. It is easy to observe that the model's forecast of COD is quite near to matching the actual data. This implies that the rise in the amount of COD can be entirely explained by the higher TSS at the clarifier effluent (contributing to particle COD), as well as the increased COD in the feed influent, and that there was not a hazardous event that had place.

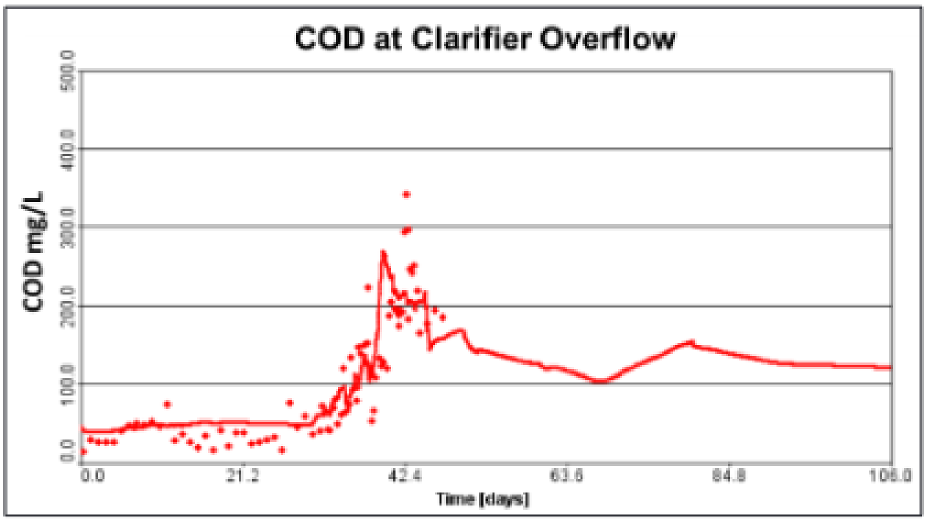

Fig 6: Model prediction and actual results of COD at clarifier overflow during surfactant ingress event

It is also possible to notice in Figure 7 that the effluent water showed comparatively low effluent ammonia levels of fewer than eight mg/L notwithstanding higher influent TKN values that were around 180 mg/l.

This points to the fact that nitrification was successful and that there was no restriction of nitrifiers taking place.

There have been reports that bacteria that oxidize ammonia are ten times more susceptible to the toxicity of organic chemicals compared to bacteria that oxidize nitrite and heterotrophs [4]. In general, smaller concentrations of pollutants are able to prevent nitrifying activated sludge as compared to non-nitrifying activated sludge [5]. This lends credence to the idea that the surfactant incursion did not have an effect that was significantly inhibitory on either the heterotrophic oxidation or the autotrophic nitrification processes.

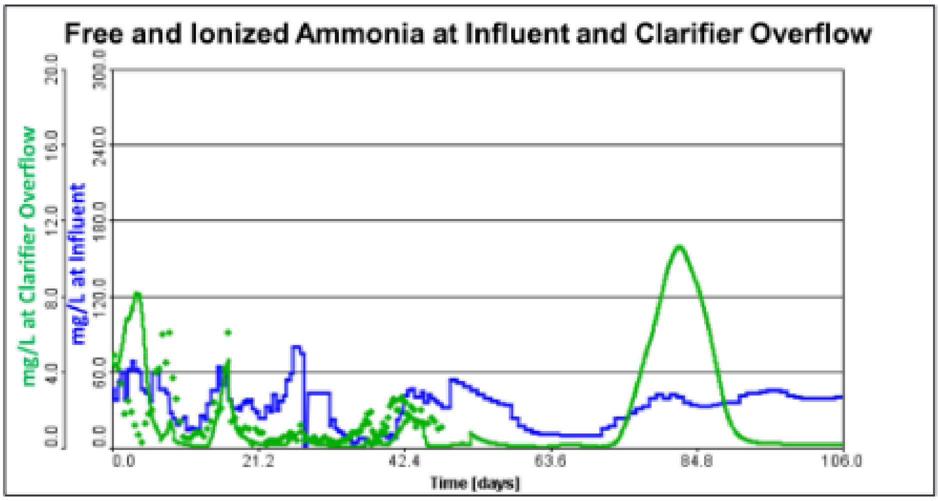

Fig 7: Model prediction and actual results of NH3-N at clarifier overflow during surfactant ingress event

Figure 8 depicts the relative surfactant concentration that was present during the event, superimposed with the flowrate of the influent feed. The figure demonstrates that it is reasonable to anticipate that the surfactant levels in the activated sludge plant will steadily decrease until they approach less than one percent of the starting concentration 24 days after the surfactant intrusion. At these concentrations, it was anticipated that the surfactant levels will have decreased to concentrations low enough to have eliminated the possibility of increased TSS levels being produced at the clarifier overflow.

The results of the model allow for the overall conclusion that the surfactant ingress did not produce any obvious inhibitory influence, but it did cause a disturbance in the settleability of biomass that was present at the clarifier. It was also determined that lowering the COD influent load and isolating the surfactant in question would lead to a decrease in the quantities of TSS and COD found in the effluent.

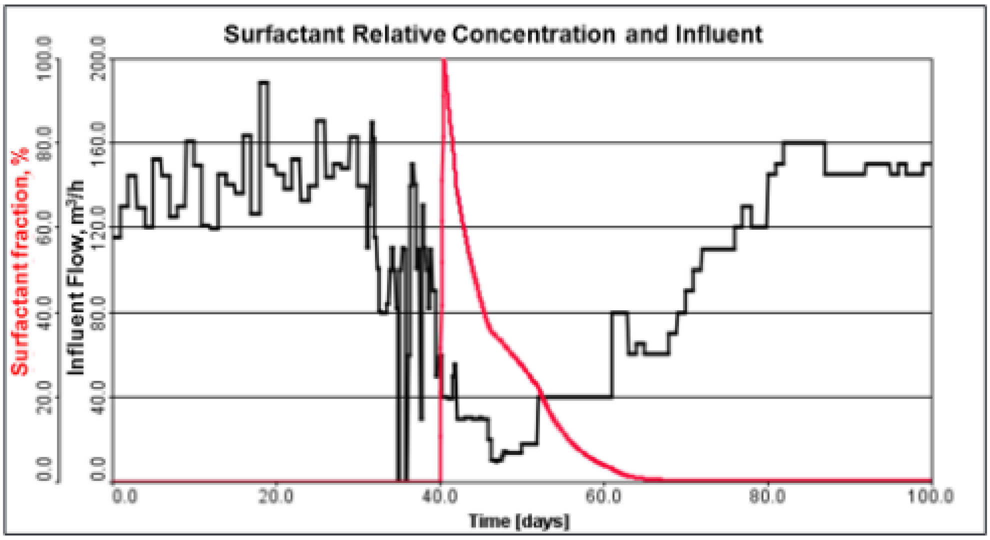

Fig 8: Surfactant relative concentration and influent flowrate during surfactant ingress event

It was noted that the levels of COD and TSS were dramatically decreased to less than 100 mg/L and 30 mg/L, respectively, around 2 weeks after the surfactant ingress event, as shown in Figure 9 and Figure 10.

This reduction can be seen in both of these figures. At this point, it is anticipated that the concentration of the surfactant will have dropped to around 15% of the value it had initially been at. Although the biomass settling has not yet returned to its optimal condition (where the TSS at the overflow is roughly 5 mg/L), it has greatly improved to the point where it is now at this level. After further interactions with the operations team, it was determined that, one month after the occurrence of the event, the IETS has resumed its usual operational circumstances.

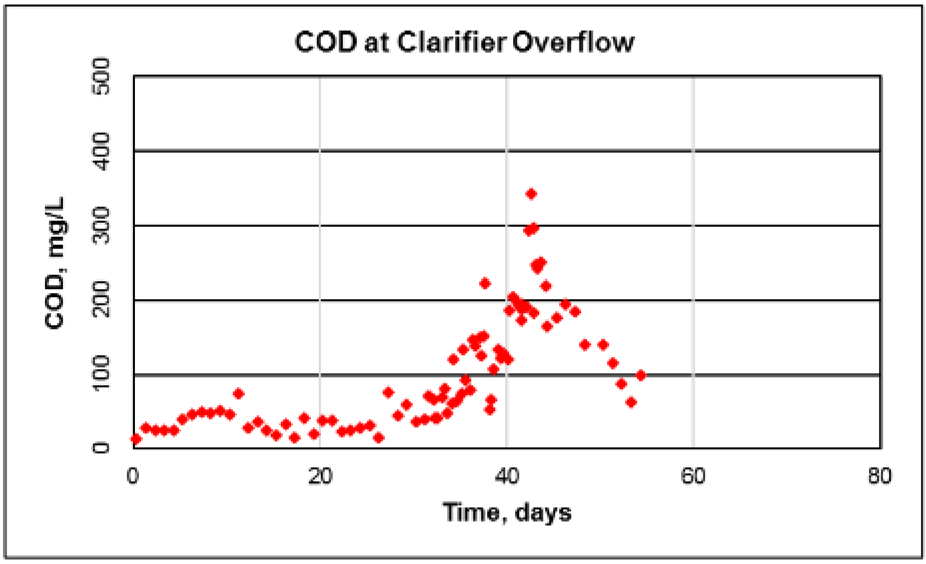

Fig 9: COD concentration at the clarifier overflow, updated 2 weeks after the surfactant ingress

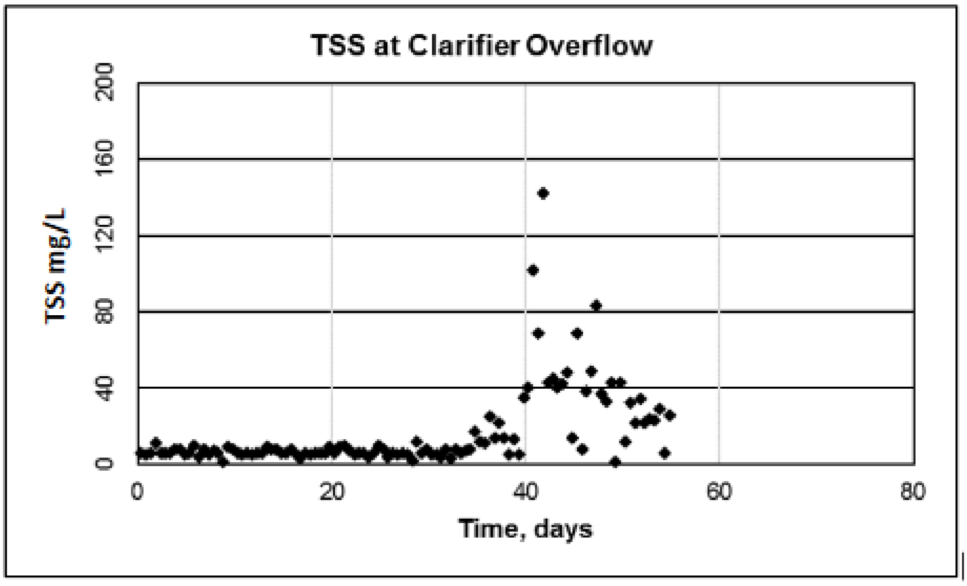

Fig 10: TSS concentration at the clarifier overflow, updated 2 weeks after the surfactant ingress

VI. CONCLUSIONS

We constructed, calibrated, and validated a model of an IETS that treats wastewater from petrochemical industries. A sensitivity analysis of the model parameters was carried out, and the results showed that the stoichiometric model parameters only have an effect on the biomass concentrations; they have no meaningful bearing on any of the other output parameters. On the other hand, kinetic parameters had an effect on every effluent parameter apart from the MLSS. The values of all the output parameters are most significantly influenced by the influent parameters.

The accuracy of the model was checked using many data sets, each of which spanned a period of three to four months. The findings indicate that the model forecast closely matched the real-world plant monitoring data, with the root mean square deviation (RMSD) for COD, NH 3 -N, and TSS being in the range of 11.7 mg/L, less than 0.52 mg/L, and less than 3.27 mg/L, respectively.

The model was utilized to provide assistance in the investigation of a surfactant ingress incident that led to plant upset, as evidenced by foaming and high effluent COD and TSS levels. This incident was caused by a surfactant entering the system accidentally.

The simulations of the model demonstrate that the surfactant ingress produced a decrease in the efficiency of the biological material settling, which led to solids carryover at the clarifier overflow and an increase in TSS and particle COD in the effluent. Concurrently, it was discovered that the COD levels in the influent water during the event were much higher than normal, which made a major contribution to the overall COD levels in the effluent.

The outcomes of the computerized simulation did not indicate that there would be any harmful inhibition of the system. It was projected that if the contaminating stream was isolated and the COD influent load was reduced, the settleability of the biomass would improve, which would result in lower levels of total suspended solids (TSS), particle COD, and soluble COD. As a direct result of this, there was an anticipated decrease in the COD content of the effluent.

A subsequent follow-up with the IETS operations crew demonstrated that, as expected, the TSS and COD levels at the clarifier overflow improved, and the system progressively recovered to normal operational ranges.

According to the findings of this study, operational troubleshooting can benefit greatly from the utilization of wastewater plant algorithms that have been appropriately constructed and calibrated. As a result, it is advised that plant operators construct such models in order to aid them in ensuring compliance with discharge regulations and continuous operational excellence.

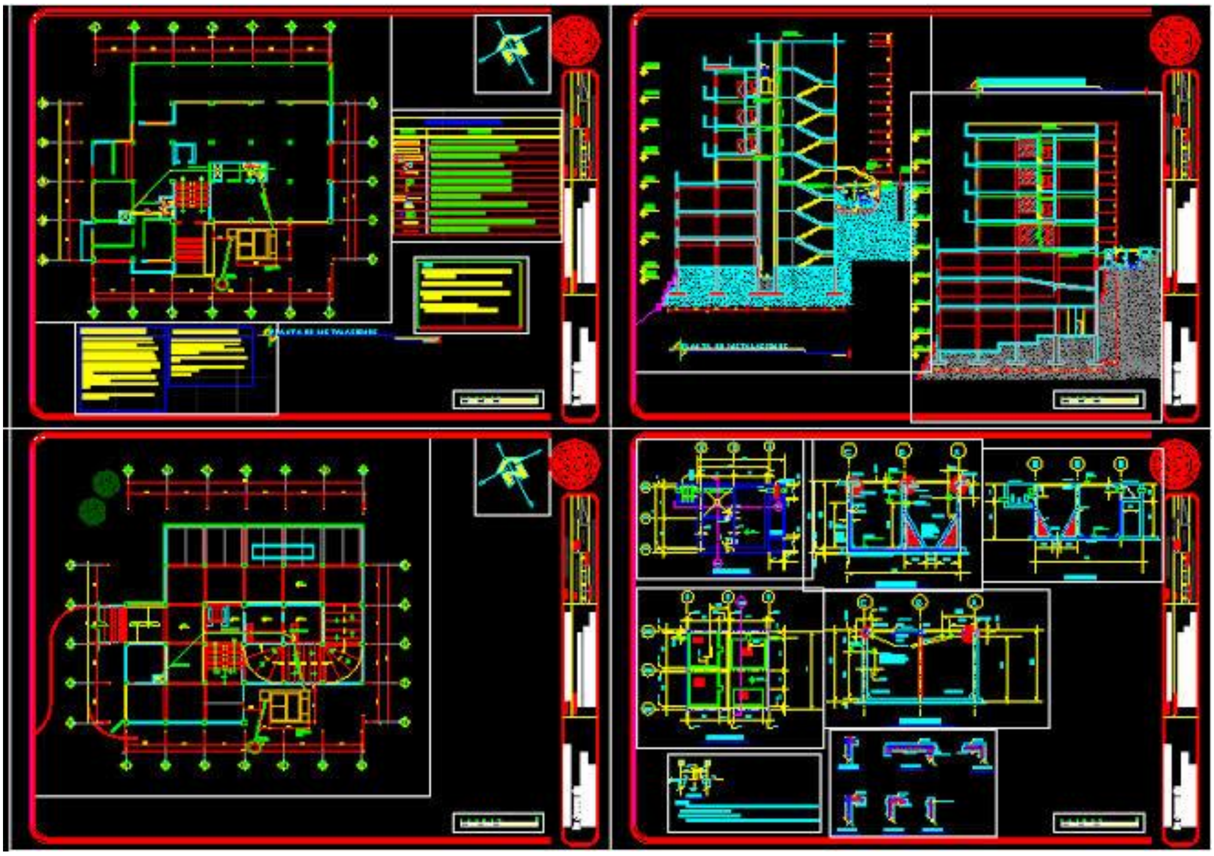

Fig 11: Piping design for waste water treatment plant in Eleme Petrochemical

The piping procedures for a waste water treatment plant in Indorama Eleme Petrochemical would typically involve several key steps. Here's a detailed explanation of the process:

- Design Requirements: The first step is to determine the design requirements for the waste water treatment plant. This includes factors such as flow rate, pressure, temperature, and the specific chemicals or contaminants present in the waste water.

- Piping Layout: Once the design requirements are established, the next step is to create a piping layout. This involves determining the optimal routing of the pipes within the plant, considering factors such as space availability, accessibility for maintenance, and safety regulations.

- Pipe Sizing: Proper pipe sizing is important to ensure efficient flow and to accommodate the required flow rates and pressure drops. It involves determining the appropriate diameter of the pipes based on factors like the maximum flow rate and the friction losses.

- Material Selection: The choice of piping material is crucial for a waste water treatment plant. It should be able to withstand the corrosive nature of the waste water and be chemically resistant. Common materials used include PVC, HDPE, stainless steel, and ductile iron.

- Pipe Support and Anchoring: Proper pipe support and anchoring are essential to prevent excessive stress on the pipes and ensure their stability. This includes using supports like clamps, hangers, and brackets at regular intervals, as well as providing expansion joints where necessary to accommodate thermal expansion.

- Pipe Routing and Connections: The actual routing of the pipes involves connecting various components such as pumps, valves, filters, and tanks. Care should be taken to minimize the number of bends and fittings to reduce friction losses and pressure drops.

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- Welding and Jointing: Depending on the chosen piping material, welding, or jointing techniques such as solvent welding, butt fusion, or mechanical joining may be used. These techniques ensure secure and leak-free connections between the pipes and fittings.

- Testing and Inspection: After the installation of the piping system, it is important to conduct thorough testing and inspections to ensure its integrity. This may include pressure testing, leak detection, and visual inspections to identify any potential issues or leaks.

- Documentation and As-Built Drawings: Lastly, it is crucial to maintain accurate documentation and as-built drawings of the piping system. This helps with future maintenance, troubleshooting, and any potential expansions or modifications to the waste water treatment plant.

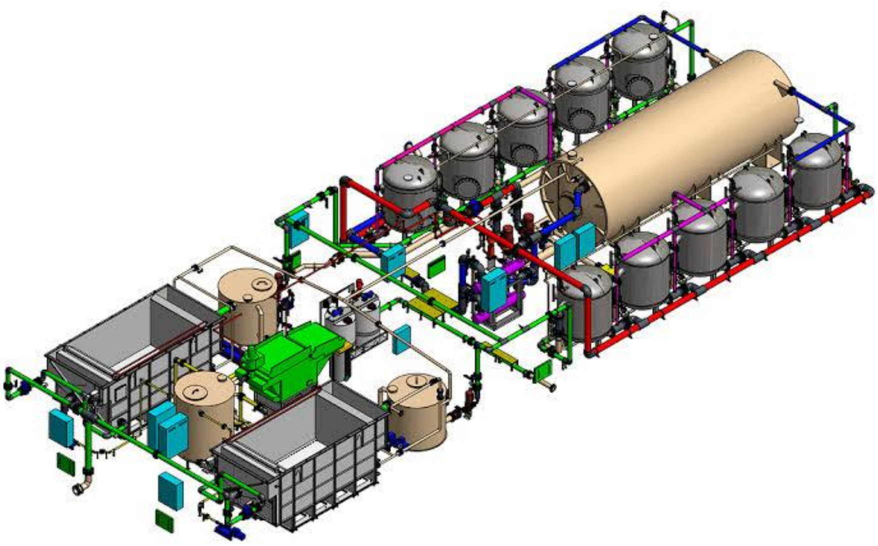

Fig 12: Waste water treatment plant

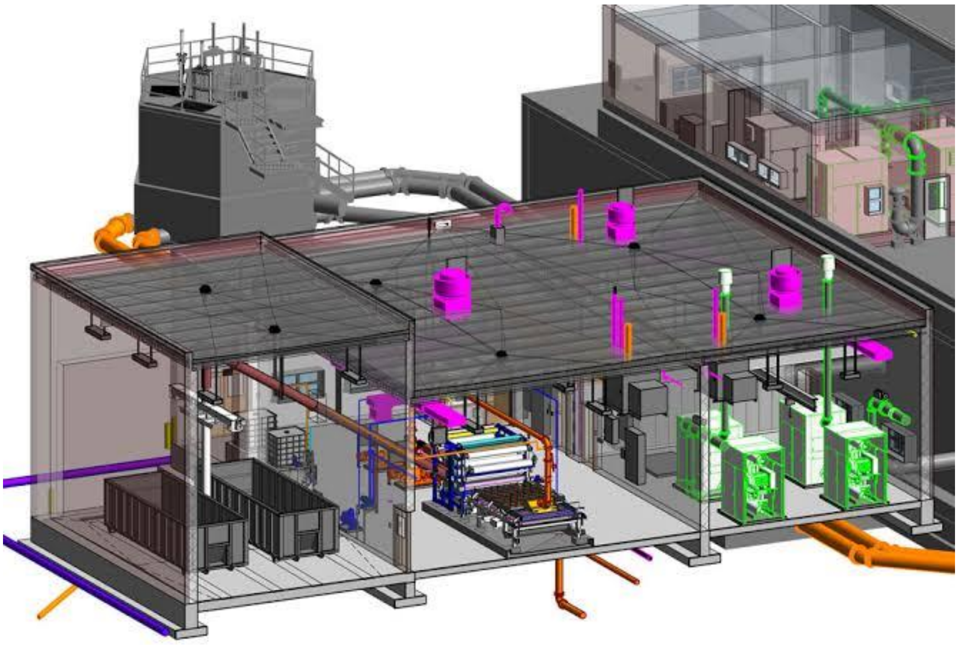

Fig 13: Customized petrochemical waste water treatment plant

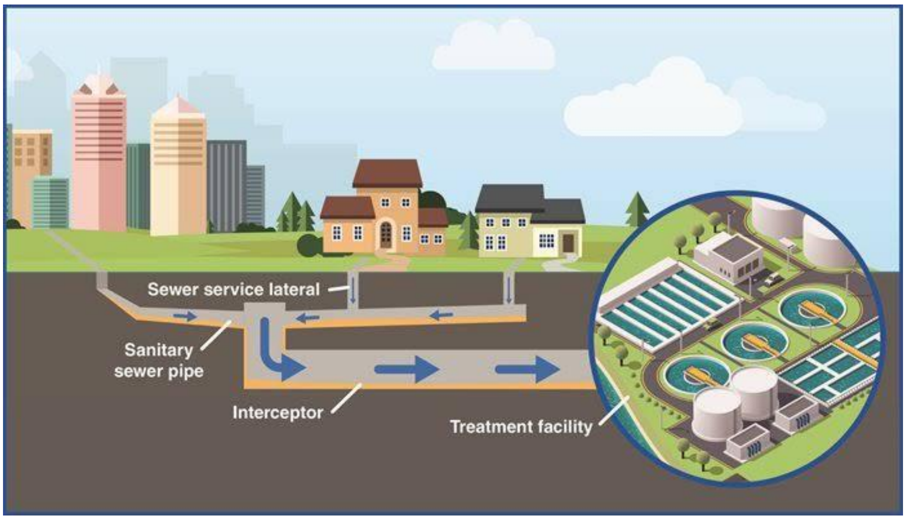

Fig: 14: The overview of Indorama Eleme Petrochemical Waste water treatment

RECOMMENDATION

Here are five suggestions for investigating the effective treatment of petrochemical wastewater using modern wastewater plant simulation software:

- Use sophisticated modeling: Using advanced simulation software that integrates computational fluid dynamics (CFD) and process modeling, you may gain a complete understanding of flow patterns, reaction kinetics, and mass transfer within the wastewater treatment process. This can aid in the optimization of treatment efficiency and the identification of possible bottlenecks.
- Improve chemical dosage: Advanced modeling software can mimic the impacts of various chemical dosing tactics, enabling for the most effective use of coagulants, flocculants, and other chemicals. This optimization can improve pollutant removal, minimize chemical consumption, and increase cost-effectiveness.
- Improve energy efficiency: Simulation software can assist in identifying possibilities for energy optimization throughout the treatment process. The program can advise adjustments to minimize energy usage by monitoring the energy consumption of various components (such as pumps, aeration systems, and mixers), resulting in cost savings and environmental advantages.
- Integrating simulation software with real-time data monitoring systems allows for continuous assessment of process performance and early identification of deviations or problems. This proactive strategy enables prompt modifications and remedial measures, resulting in consistent and efficient treatment operations.
- Conduct virtual scenario analysis: Simulation software may model various operational situations, such as changes in feed flow rate, pollutant composition alterations, or the introduction of new treatment technology. Operators may examine the potential consequences on the treatment process, troubleshoot any difficulties, and make educated decisions by digitally analyzing these scenarios before implementing changes in the actual plant.

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