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Integrated Fixed-film Activated Sludge (IFAS) Process–A Comfortable Upgrade for Upgrading of Existing Wastewater Treatment Plants

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Abstract—*India's huge and growing population is putting a strain on all of the country's natural resources. Supplying safe drinking water to all communities is a problem itself, but India is facing a major problem of surface water resources being contaminated by sewage and agricultural runoff. Now in India, diarrhea alone is causing more than 1600 deaths daily, this is because of improper disposal of sewage to natural sources. So proper treatment and monitoring of sewage and its disposal are mandatory, in this case up gradation of existing treatment methods and processes is necessary. In this paper, it is reviewed how Integrated Fixed-Film Activated Sludge (IFAS) process is comfortable for upgrading an existing wastewater treatment plant to required efficiency and standards. IFAS process is a biological treatment method where a medium is introduced into the waste water. If introduced, it will be very useful in India because of our tropical climate.*

Keywords*: IFAS process, Nitrification, Upgrading WWTP, biofilm*

1. INTRODUCTION

Proper treatment of wastewater is being pressurized in recent days. If improperly treated wastewater runoff is released into the river or a water body for long durations then it will lead to heavy damage to the water body. Hussain Sagar Lake in Hyderabad is one of the live examples of this phenomenon. Hussain Sagar Lake was a water body dug to supply drinking water to the city in drought. But as time passed all nearest industries, urban developments started disposing their wastes into Hussain Sagar Lake untreated and also sewage is disposed of for decades. An unplanned and unmonitored disposal of wastewater leads to dangerous and regretful results. So, proper treatment and monitoring are a mandatory for wastewater treatment.

When a statistical analyses of 10 year record of stream nutrient and sediment concentrations for 17 streams in the greater Seattle region was conducted to determine the impact of non-point source pollutants on stream water quality, most urban streams on average had 95% higher total phosphorus (TP) and 122% higher soluble reactive phosphorus (SRP) and 71% higher turbidity than the most streams[1]. According to this study, nitrogen did not vary considerably, but phosphorus concentrations were high. When municipal and industrial wastewater effluents are discharged to these ephemeral or intermittent streams, effluents may comprise the majority of stream flows [2], [3]. Effluent-dominated and dependent streams, hereafter effluent-dominated streams have unique water quality characteristics that, in most cases, are comparatively different from normal stream conditions upstream of the discharge or at regional reference sites[2], [4]. Stream flows in the Trinity River Basin, Texas, and the South Platte River Basin, Colorado, can be 90% or greater dominated by effluent flows[2], [3]. The impact of National Fertilizer Company of Nigeria (NAFCON) outfall effluent on the physiochemistry and bacteriology of Okrika creek was investigated during the sampling period from May to December 1998. The NAFCON effluents include domestic and sanitary sewage, ammonia and urea plant condensate, steam condensate, contaminated run-off, storm water and utility wastewaters. These effluents contain toxic components such as free ammonia, numerous ammonium compounds, phosphate compounds, and urea, heavy metals from chemicals used in establishing production processes, oil, grease and fuel from machinery[5]. After the study, it is observed that Okrika creek has higher concentrations of various bacterial species than control creek. All important parameters like concentrations of inorganic and organic constituents were observed to be on higher than Federal Environmental Protection Agency (FEPA) standards for industrial effluent in control creek and other Okrika creek stations[5].

2. IFAS PROCESS

In this process a medium/carrier is introduced into the suspension in the wastewater it moves around freely in the mixed liquor. The biomass in wastewater gets attached to this biofilm while consuming nutrients and organic substances in WW as food for their growth with oxygen through aeration for the reactor. Because of this, impurities in WW are removed thus enhancing the treatment and improving the efficiency of the treatment plant. In the simplest definition, IFAS takes a conventional activated sludge wastewater treatment plant and adds into its existing aerobic basins some form of media to help the slower growing bacteria, mainly nitrification type bacteria to inhabit the media[6]. Currently, there are two types of media categories in the market, fixed media, and free floating media. The basic intent of IFAS process is to provide additional biomass within the reactor volume of an activated sludge process of increasing the capacity of the system or upgrading its performance[7]. By allowing the fixed film phase to retain biomass in the basin the IFAS process can be operated at low Sludge Retention Time (SRT) and still achieve nitrification, because of retained biomass in the fixed film, this controls the effective SRT. By maintaining a low SRT in the IFAS basin, it was feasible for the better settling of sludge with lower SVI compared to conventional activated sludge process[8].

Fig. 1- Shows the different types of media that are being used in the IFAS process worldwide [19]

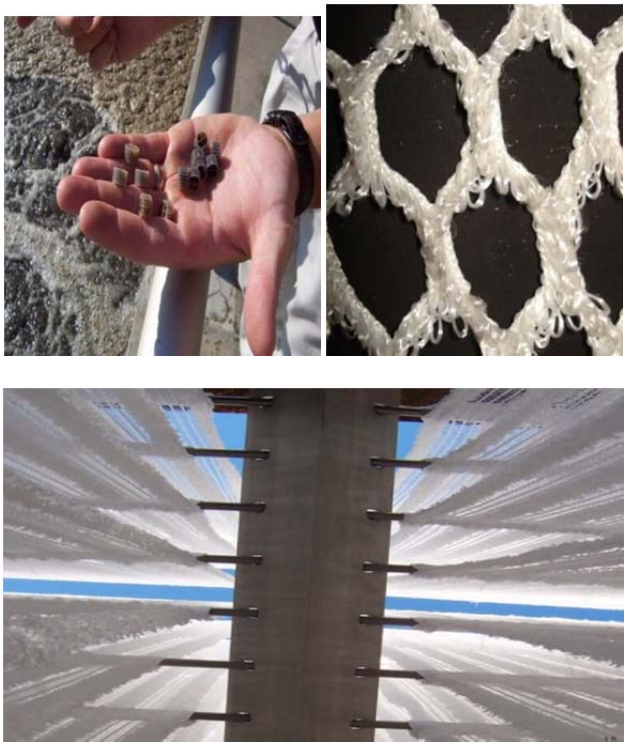

Fig. 2: Shows the formed biofilm of the media used in treatment process [19]

3. CASE STUDIES

In the City & County of Broomfield Wastewater treatment plant, secondary treatment processes were upgraded to IFAS process in 2003. Because of increasing population city was adding treatment processes to reuse a large portion of its wastewater as reuse irrigation water and restricted Total Nitrogen (TN) and Total phosphorus (TP) were set to reach these levels IFAS process was chosen as upgrading method.

Table 1: Effluent requirement objectives [9]

Parameter	Effluent requirement
BOD	<10 mg/L
TSS	<10 mg/L
NH3-N	<1.5 mg/L – Summer <3.0 mg/L - Winter
TIN	<10 mg/L
TP	<1.0 mg/L

Results observed were very satisfactory with 93% ammonia removal, 98% nitrite/nitrate removal, 116% alkalinity removal, 93% TSS removal, 101% biofilm mass, all targets for nitrification and Denitrification were reached[9][10].

A treatment plant including petroleum refinery in Cheyenne, Wyoming utilized IFAS technology for upgrading their existing wastewater treatment plant .In August of 2006, the WWTP received a new effluent discharge limit of 2.18mg/L ammonia on an average month basis. A rate of 0.42 gm NH_3-N/m^2/day was used to determine the minimum amount of moving bed media required for nitrification. Using this design rate 240 m^3 of media volume was required which is about 13% fill fraction of the volume of two aeration basins. Media was slowly added to the reactors from early July of 2007. By mid-August effects of forming additional biomass and better efficiency were observed. Ammonia removal of 73% was observed even with a small fraction of media introduced[11].

In a chemical plant located in orange, Texas, IFAS process was used to update a poorly performing activated sludge type sewage treatment plant. The main operational problem was because of high influent water flow rates, variable wastewater characteristics, loss of biomass through the clarifier. The permit requirements were 20 mg/L BOD, 20 mg/L TSS, and 3 mg/L NH_3-N. With new update IFAS system, the plant not

only met its permit requirements consistently but also was able to decrease chemical costs by lowering a number of chemicals for chlorination and de chlorination[11].

For a specialty chemical company in Conroe, Texas, IFAS process was used to upgrade an existing activated sludge plant. The plant was experiencing a severe washout of biomass in the aeration tanks due to large variations in influent wastewater characteristics. Past operational data indicated that COD of influent wastewater to the aeration tanks varied from 240 mg/L to 2400 mg/L, influent ammonia nitrogen concentrations varied from 0 mg/L to 8 mg/L, with these wide variations in influent loading rates, it was difficult to maintain the required MLSS in aeration tanks. It was observed that after aeration tanks were converted to IFAS process in 2006, the performance was more stable and had consistently produced a good effluent quality of 40 mg/L BOD, 40 mg/L TSS, and 5 mg/L NH_3-N[11].

In a research, the efficiency of a new version of an IFAS reactor was studied at pilot plant scale in Ekbatan municipal WWTP in Tehran, Iraq. In this new reactor aerobic, anoxic and anaerobic zones were designed in a single reactor, and as a result, the conditions of doing nitrification, Denitrification, phosphorus removal and increasing BOD removal rate in the reactor were optimized. For the plant with raw wastewater characteristics as 200 mg/L TSS, 150 mg/L BOD, 240 mg/L COD, 45 mg/L TKN, 12 mg/L TP, as days passed it was observed that COD, BOD, Nitrogen and Phosphorus removal is consistent and efficiency is ascending. From this study, it is concluded that IFAS process can be a less expensive alternative for upgrading existing wastewater treatment plants to increase the capacity of organic loading removal rate and nitrification. In fact, the successful operation of the IFAS reactor, as indicated by the measured COD, was further supported, well within expected range, removals of ammonia and phosphorus[12].

For a comparison study between Integrated Fixed-Film Activated Sludge (IFAS), Membrane Bioreactor (MBR) and Conventional Activated Sludge process, a mathematical model was used for investigating the performance and treatment capability of three proposed processes at three different loadings. The GPS-X (Version 5.0) simulation program was used in this study to simulate these three processes. The influent wastewater flow rate set for this mathematical model was 45000 m^3/ d.

Table 2: Concentrations of parameters taken for model in simulation study[8]

Parameter	Case 1 low concentrations	Case 2 medium concentrations	Case 3 high concentrations	Units
Total SS	180	250	375	g/m3
Volatile SS	135	188	281	g/m3
Total organic SS	45	62.5	93.8	g/m3
Total BOD	225	300	450	gO2/m3
Total COD	408	548	807	gCOD/m3
TKN	25	35	50	gN/m3

After simulation of three considered processes at three various concentrations, the results obtained for IFAS process are like this. The treatment efficiency of the IFAS system based on BOD removal is ranged between 97.7 to 98.2%, based on BOD was between 97.7 to 98.19% and based on TKN was between 97.2 to 98.7%. It was also observed that IFAS system has a high treatment efficiency and good ability to receive the organic shock loads[8].

In 1997, the city of Greensboro, for North Buffalo Plant due to various loading and increasingly stringent effluent requirements, Greensboro was in need to increase their biomass to allow consistent nitrification without the significant capital investment of additional tankage. So for the 16 MGD plant, they adopted an Accuweb media system to one of their flow trains in 1997. Since installation, the plant consistently met discharge limits and an average 24% better ammonia removal than the other three trains, this simple installation improved nitrification in the whole plant and system did not face any maintenance problems from then[13].

For Peterborough Wastewater treatment plant an increase in the Average Daily Flow (ADF) from 60000 m^3/ d to 68200 m^3/ d was expected to reach this and handle peak flows up to 190900 m^3/ d and still maintain standards, IFAS process was chosen as an update for this plant and this plant was under study for 15 months and efficiencies of the plant in the cold temperatures was also observed. Plant reached a Total Ammonical Nitrogen (TAN) removal limit of 5 mg/L after 3 months of installation consistently. All other parameters including CBOD, TSS, TP, E.coli and unionized ammonia were observed to be well below effluent objectives for the duration of the long-term stress test. This plant has demonstrated the ability to meet effluent objectives operating as an IFAS process at the proposed ADF throughout the long term stress test, which includes extreme weather conditions related to both increased hydraulic and organic loading as well as temperature[14].

In a paper performance of Ten full-scale wastewater treatment facilities applying IFAS and MBBR systems were evaluated using a Unified model for Activated sludge, IFAS and MBBR systems. At each facility, the model was applied to compute the biofilm surface area required to achieve nitrification based on the plant loading, mixed liquor temperature, and aerobic mixed liquor MCRT. The Effluent ammonium-N was then computed for the amount of biofilm surface area installed and

compared to the plant effluent. The analysis showed that the model was able to accurately predict the performance of the facilities. From this study it was concluded that IFAS can be applied to compute a threshold value for biofilm surface area that is required for each plant, they may be upgraded with biofilm support media to achieve nitrification. By application of Unified model on ten full-scale facilities showed that if the quantity of media met the threshold, the facility was able to nitrify (achieve < 2 mg/L effluent ammonium-N in winter)[15].

4. CONCLUSIONS: FROM ALL THESE CASE STUDIES

- IFAS process is proven to be a comfortable and efficient upgrade for the improval of efficiencies of an existing poorly performing WWTP
- IFAS process has faced many of the complex problems in maintenance of many WWTP's and reached set effluent objectives
- Varying hydraulic loading, organic loading, increasing influent flow, stressing effluent standards, low temperatures or loss of biomass, IFAS process was able to handle all these complexities
- Upgrading an existing plant to IFAS system is very easy, for an Accuweb installation in North Buffalo plant it only took 5 days for total installation and upgrading a single train of four improved the capability of the whole plant
- IFAS process can handle shock loads, extreme stress situations, temperature variations and various characteristics of raw wastewater
- After primary installation in an IFAS reactor, operation cost for aeration is the major contributor
- As long as the system is properly maintained IFAS process can function efficiently for decades without any major problems
- Chosen medium can be introduced into the reactor easily

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