APPLICATION OF BIOLOGICAL AERATED FILTER FOR TREATING CATTLE ABATTOIR WASTEWATER

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Abstract: Aerated Biofilter Reactor (ABR), also known as Biological Aerated Filtration (BAF) was designed, constructed for wastewater treatment for a cattle abattoir. The objective of this study is to monitor the performance of the Submerged Upflow Aerated Biofilter Reactor (ABR) system by using polyethene (PE) as media and evaluating the efficiency in removing pollutants. The reactor performance was examined with organic strength up to 930 mg/L BOD_5, at hydraulic loadings up to 1.8 kg m^{-3} d^{-1} and surface organic loadings up to 4.4 kg m^{-2} d^{-1}. The performance of the reactor was evaluated based on the values of biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solid (TSS), ammonia nitrogen (AN), oil and grease (O & G) and turbidity. The reactor demonstrated the capability of removal efficiencies for BOD_5 ranging from 83% to 96%, the system performance slightly deteriorated with time. Overall, for total suspended solid (TSS), 93% reduction was observed and consistently lower than 100 mg/l. The effluent criteria were also monitored for the removal efficiencies of biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), ammonia nitrogen (AN), oil and grease (O & G) and turbidity. BAF system has shown the average elimination rates of 91%, 88%, 24%, 40%, and 91% respectively. Based on demonstrated performance, the BAF reactor was viable for the cattle abattoir wastewater treatment and met the effluent discharged criteria stated by Malaysia Environmental Quality Act in effluent discharge for BOD_5, COD and TSS.

Keywords: Cattle Abattoir wastewater, Aerated Biofilter Reactor, Removal Efficiency

OUTLINE

- INTRODUCTION
- SIGNIFICANCE AND OBJECTIVES OF THE STUDY
- MATERIALS AND METHODS
- RESULTS AND DISCUSSION
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INTRODUCTION

- Wastewater from abattoir is one of the **pollution sources**
- Uncontrolled use of water leads to overloading **higher contents** of **organic** waste (Jensen *et al.*, 2016)
- **Improperly** Treated & Discharged wastewater potential threat to public health and the environment (US EPA, 2004)
- > 65% of the freshwater used *spraying, rinsing & cleaning activities* (Yung et al., 2005)
- Remaining 35% of the water attributed to *cooling water, animal handling facilities, tools sterilization, vehicle washing and personal hygiene.*
- Wastewater generated **during and after the operation** considered as **high strength wastewater** due to **high level** COD; Oil & Grease , Nitrogen, total suspended solids and colloidal compounds – bloods,protein and cellulose (Davarnejad et al., 2012)
- The strength may differ from one industry to another – **number & types** of the animal slaughter & operational process

SIGNIFICANCE OF THE STUDY

- Very little information about abattoir wastewater characteristics in Malaysia.

- There is a need to know the effect of a compact system using Biological Filter process in treating abattoir wastewater.

- Production of high-microbial concentration per unit volume, so that improves the organic removal efficiency of pollutant parameters.

- Cost-effective in terms of small area requirement and facilities.

OBJECTIVES

- To monitor the performance of Submerged Upflow Aerated Biofilter system (SUABF) using *Cosmo-balls* (PE) as media.
- To meet higher effluent quality discharge standards requirements of DOE (Dept. of Environment) Malaysia.

Figure 1: Cosmo Balls Model (http://www.pakar.com.my/)

ENVIRONMENTAL QUALITY ACT OF MALAYSIA
PARAMETER LIMITS OF EFFLUENT OF STANDARD A AND STANDARD B

PARAMETER	UNIT	STANDARD A	STANDARD B
Temperature	^{0} C	40	40
pH value	-	6 – 9	5.5 – 9
BOD5 (% days at 20 ^{0}C)	mg/l	20	50
COD	mg/l	50	200
Suspended Solids	mg/l	50	100
Mercury	mg/l	0.005	0.05
Cadmium	mg/l	0.01	0.02
Chromium, Hexavalent	mg/l	0.05	0.05
Arsenic	mg/l	0.05	0.10
Cyanide	mg/l	0.05	0.10
Lead	mg/l	0.10	0.5
Chromiumum,Trivalent	mg/l	0.20	1.0
Cooper	mg/l	0.20	1.0
Manganese	mg/l	0.20	1.0
Nickel	mg/l	0.20	1.0
Tin	mg/l	0.20	1.0
Zinc	mg/l	2.0	2.0
Boron	mg/l	1.0	4.0
Iron (Fe)	mg/l	1.0	5.0
Phenol	mg/l	0.001	1.0
Free Chlorine	mg/l	1.0	2.0
Sulphide	mg/l	0.50	0.50
Oil & Grease	mg/l	Not Detectable	10.0
Ammonical Nitrogen	mg/l	10	20

Source: (DOE, 2009)

MATERIALS AND METHODS

Study Location of SUABF System at Banting Abattoir

METHODOLOGY

- Characterization of wastewater concentrations based on Standard Methods, *American Public Health Association* (APHA, 2005):
  - ✓ Biochemical Oxygen Demand (BOD5)
  - ✓ Chemical Oxygen Demand (COD)
  - ✓ Total Suspended Solid (TSS)
  - ✓ Ammonia Nitrogen (AN)
  - ✓ Oil & Grease (O&G)
  - ✓ Turbidity
- The Submerged Upflow Aerated Biofiltration System SUABF set-up
  - Evaluation of the performance of SUABF System

Slaughtering activity

Cleaning activity

Influent
(Raw Wastewater)

Solids & Fat trap

Sump

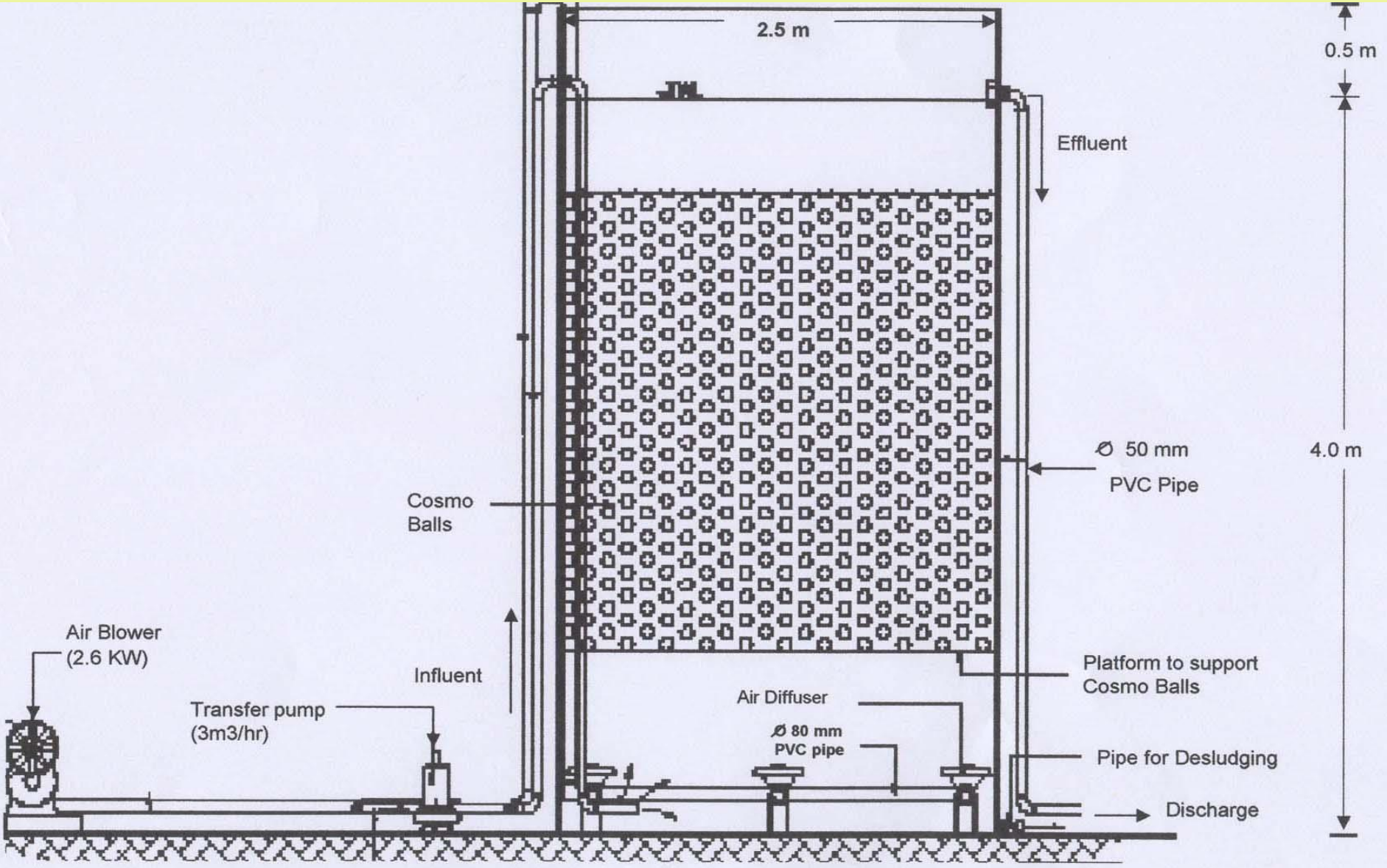
- Wastewater from an abattoir flows into a rectangular sump through a fat trap (screen).

SAMPLING PROGRAM

- Sampling Program is carried out simultaneously during the wastewater generation study.
- A composite sample is taken through individual grab samples (100 mL) through 15 minutes intervals.
- Samples of 2.0 Litres are prepared and preserved in ice bucket and transported to Lab for analysis
- Samples were analysed for such as:
  - BOD_5,COD,TSS, AN, O&G & Turbidity

Submerged Upflow Aerated Biofilter Reactor – SUABFR

(Attached Growth System)



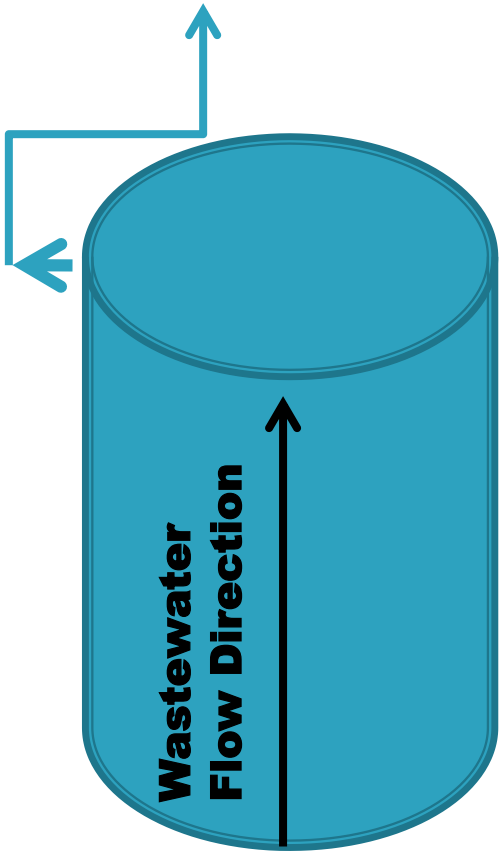
SUABF Reactor

Cosmo-balls media used as supporting biofilm growth

Blowers are used to supply oxygen

Final tank as Clarifier

overflow effluent from reactor entering the last tank (clarifier) before being discharge



Final effluent discharged sufficiently met the target of effluent quality to standard B of DOE requirements

Cosmo-Balls Material	Polyethylene (PE)
Shape	Spherical
Specific gravity	0.9
Void fraction	85%
Outer diameter	85 mm
Inner diameter	75 mm
Wall thickness	>0.5 mm
Bulk density	75 kg /m3
Specific surface area	> 160 m2/m3
Number of media /m3	>2000
BOD loading factor	up to 5 kg/m3/day
Hydraulic loading rate	0.06 m3/m2/hr

Table 1: Specification of Cosmo ball (http://www.pakar.com.my/)

RESULTS AND DISCUSSION

Table 2. Summary of Treatment Performance of Wastewater treatment plant on BOD_5, COD, TSS, AN, O&G, and Turbidity parameters

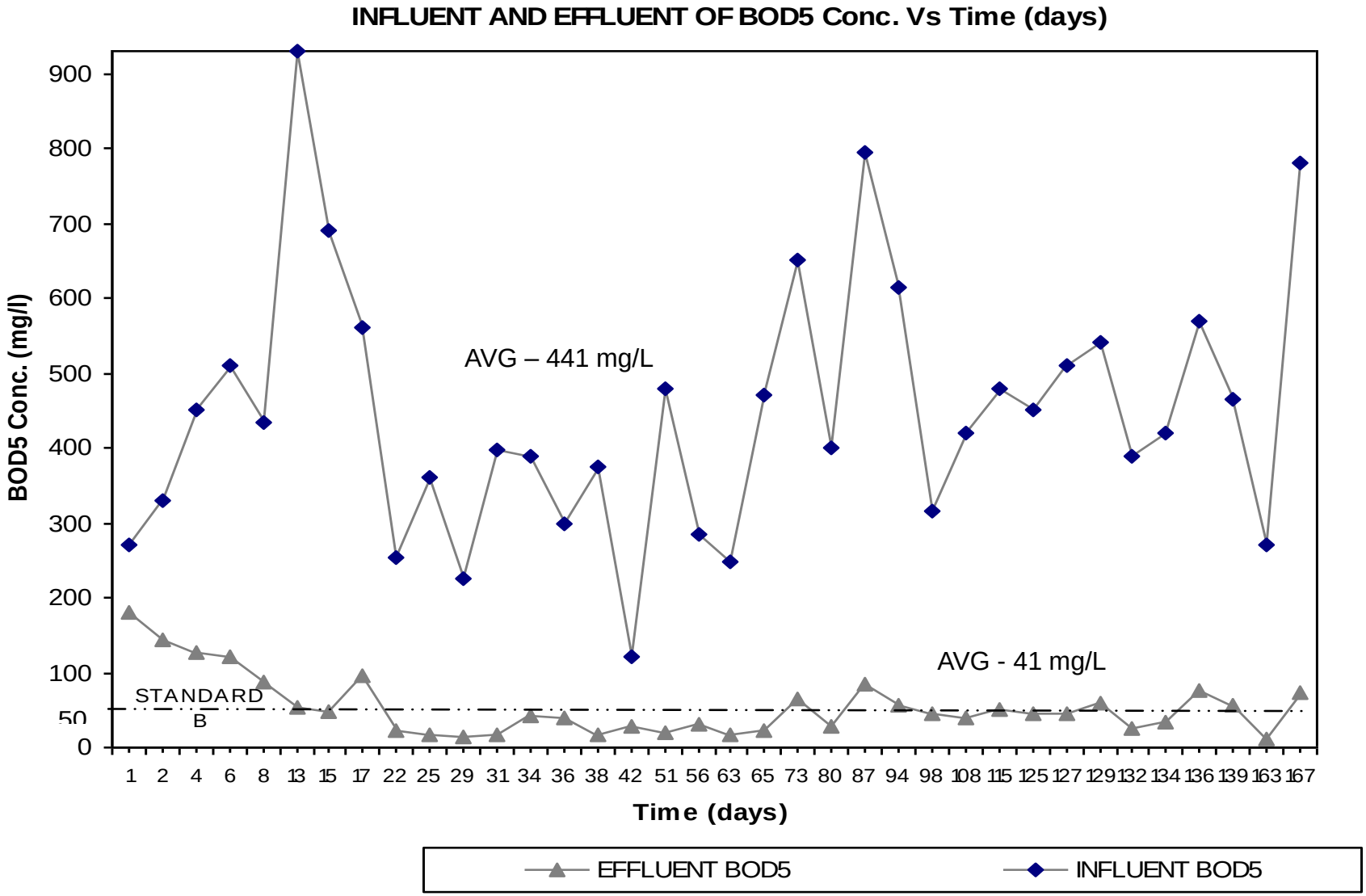
Parameters	Influent Mean ± SD	Effluent Mean ±SD	Environmental Quality Act (2009) Standard B*	Removal Efficiency (%)
Biochemical Oxygen Demand, BOD5 (mg/L)	441 ± 36.7	41 ± 54.6	50	91 ± 4.6
Chemical Oxygen Demand, COD (mg/L)	1665 ± 50.3	173 ± 47.5	200	88 ± 6.1
Total Suspended Solid, TSS (mg/L)	667 ± 48.9	40 ± 73.7	100	93 ± 8.0
Ammonia Nitrogen, AN (mg/L)	90 ± 29.4	68 ± 30.8	20	24 ± 67.2
Oil and Grease, O&G (mg/L)	87 ± 25.8	51 ± 33.0	10	40 ± 42.5
Turbidity, (NTU)	448 ± 49.4	36 ± 49.8	N.A	91 ± 4.9

N.A = Not Available

*B = Standard B used for discharge of downstream of water intake points. Standard B was used in this study.

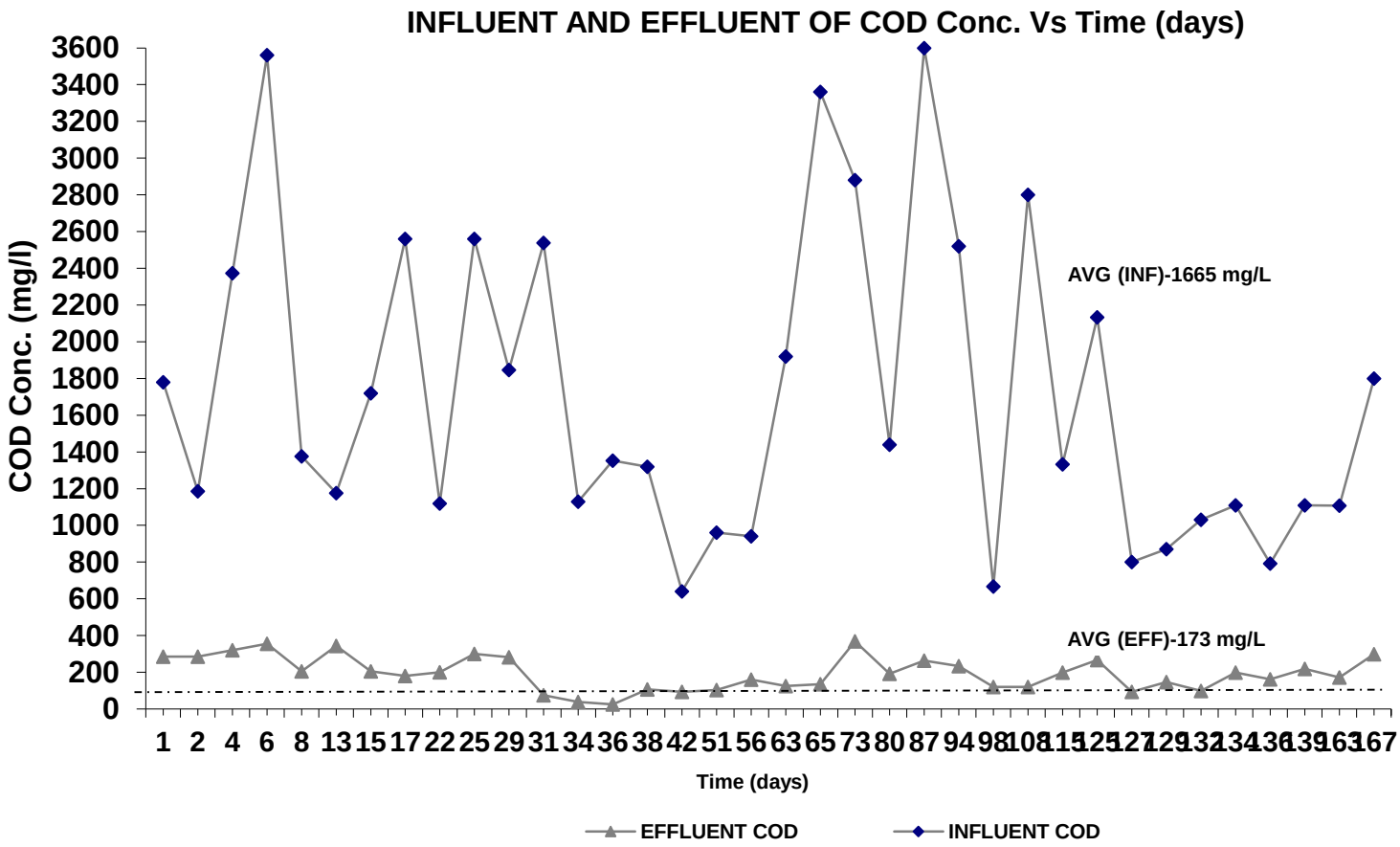
BOD5 REMOVAL

Monitoring of the influent and effluent BOD5 concentrations of the Aerated Biofilter Reactor at Banting Abattoir confirms process reliability



COD REMOVAL

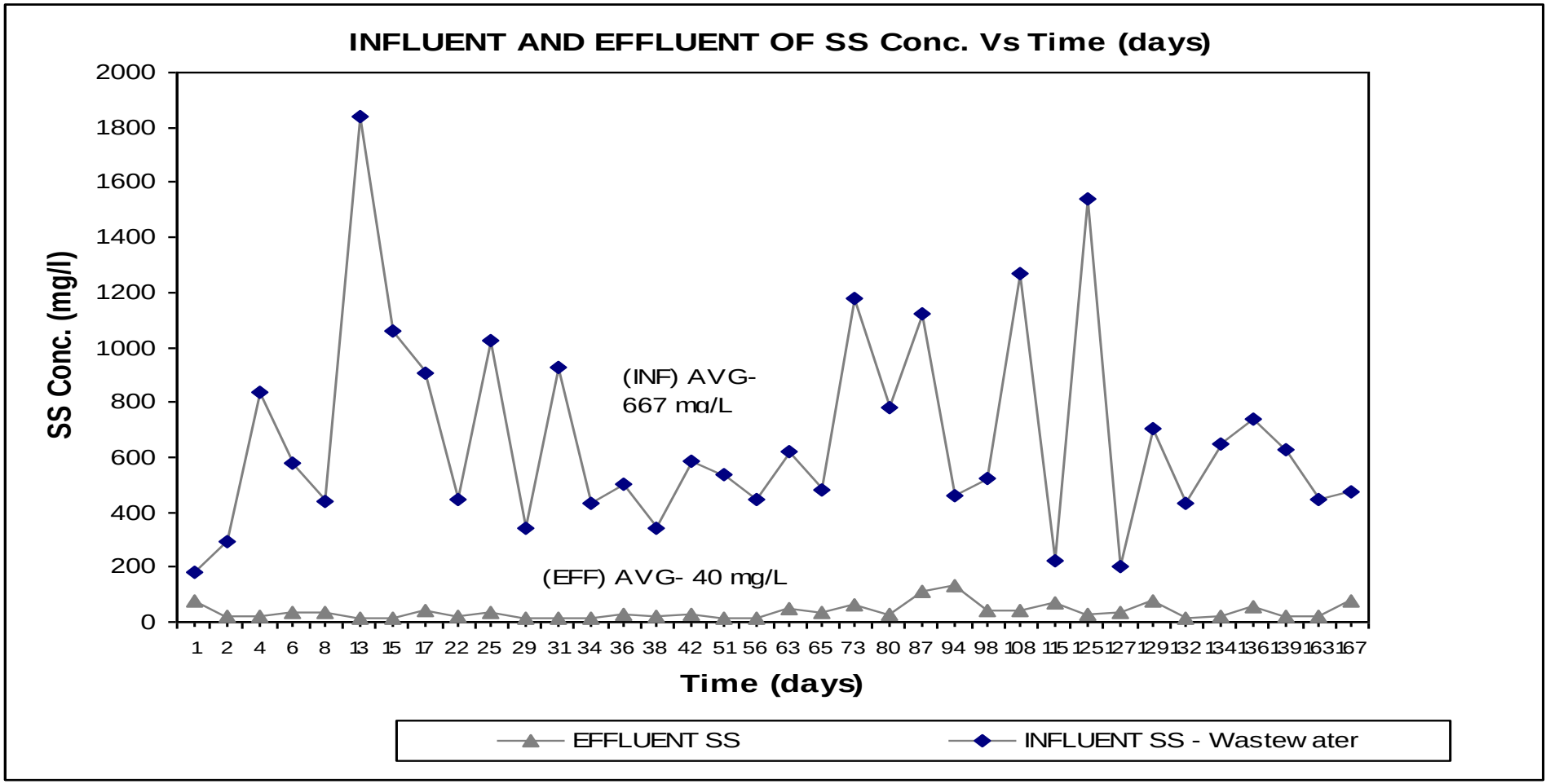
Monitoring of the influent and effluent COD concentrations



- Majority of the outflow samples had achieved with a concentration of less than 200 mg/L (level that comply with Standard B)

SS REMOVAL

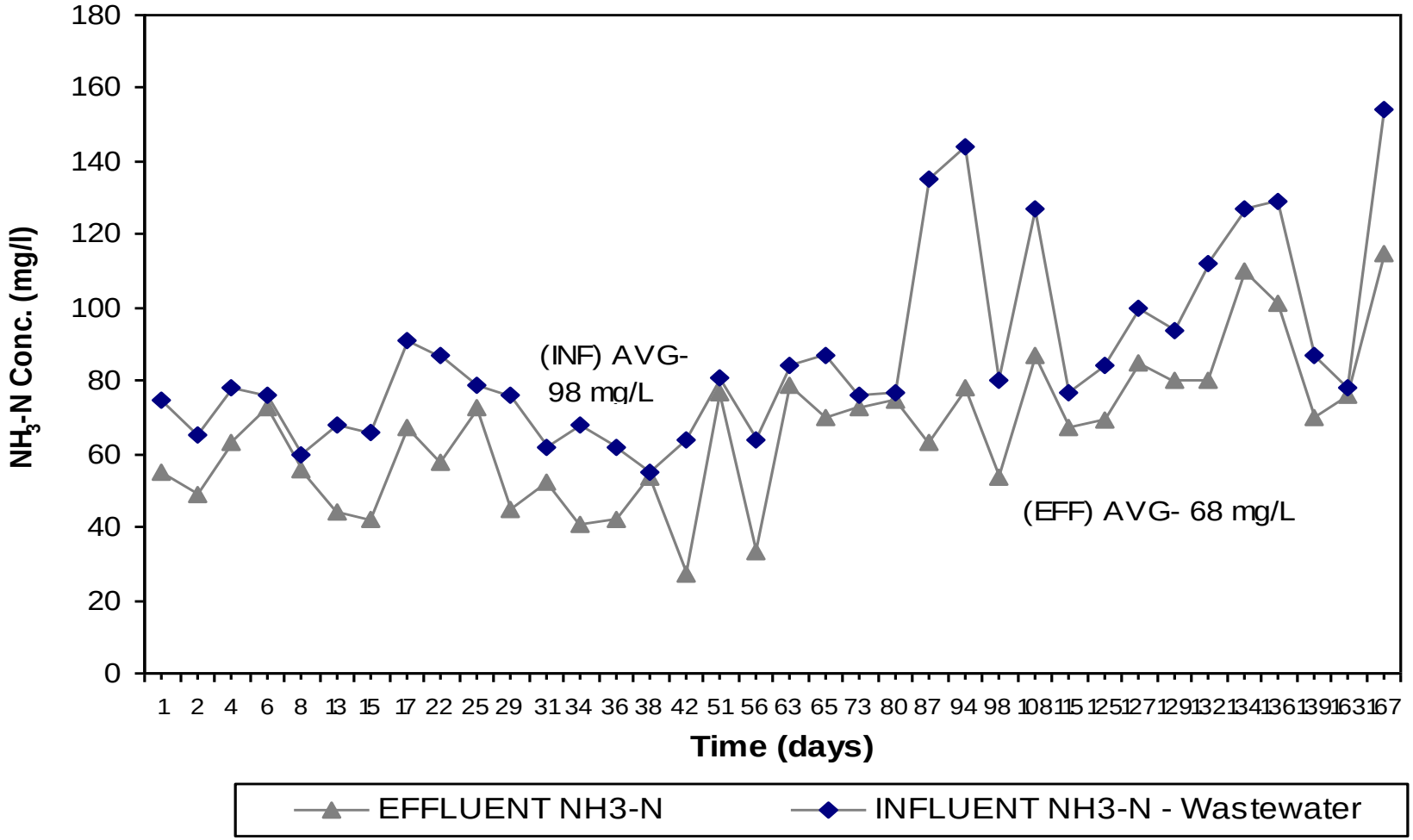
Monitoring of the influent and effluent TSS concentrations



- The results show that the outflow effluent suspended solids concentrations were generally below 40 mg/L on most occasions

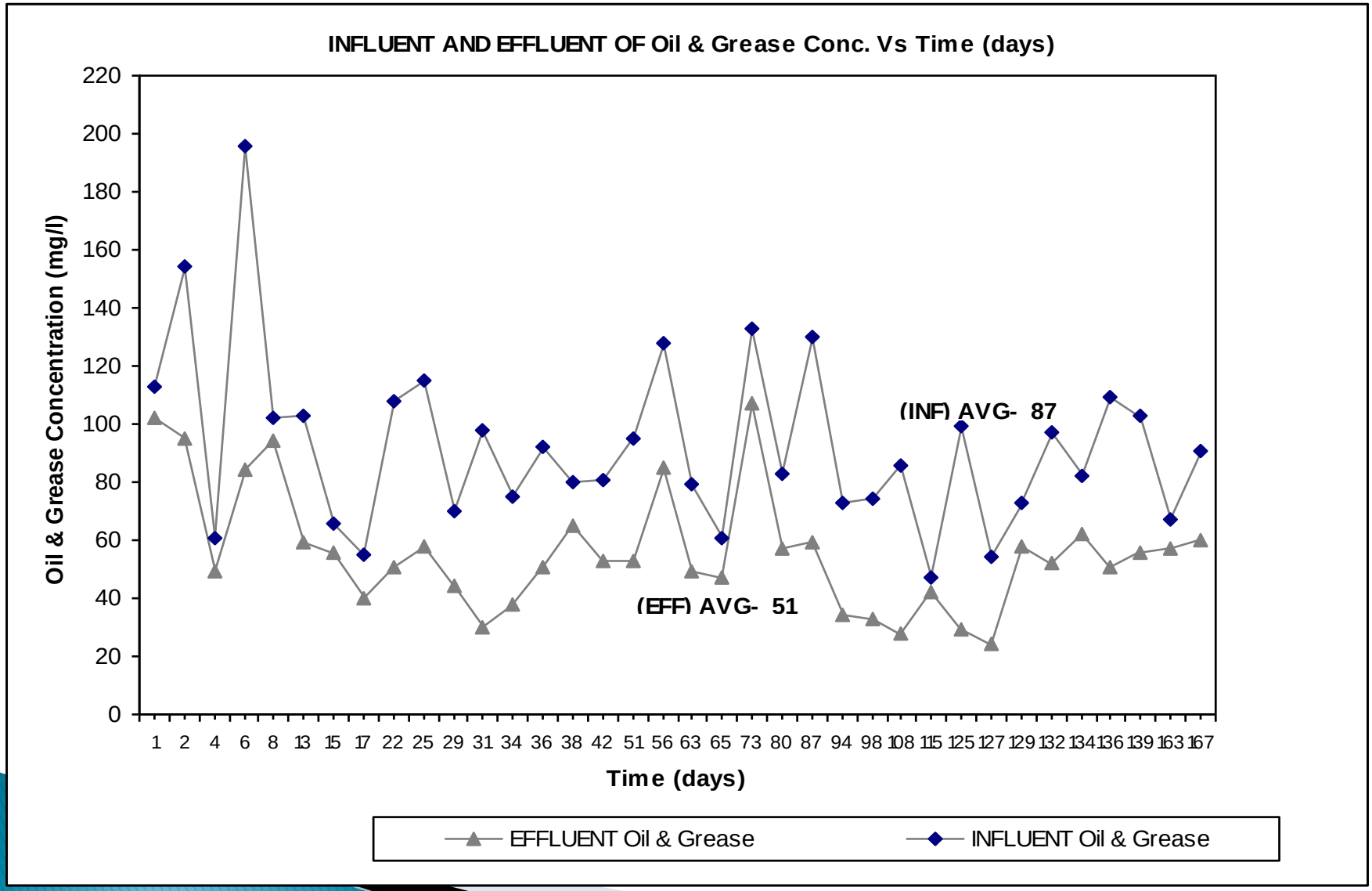
Ammonia Nitrogen REMOVAL

Monitoring of the influent and effluent AN concentrations



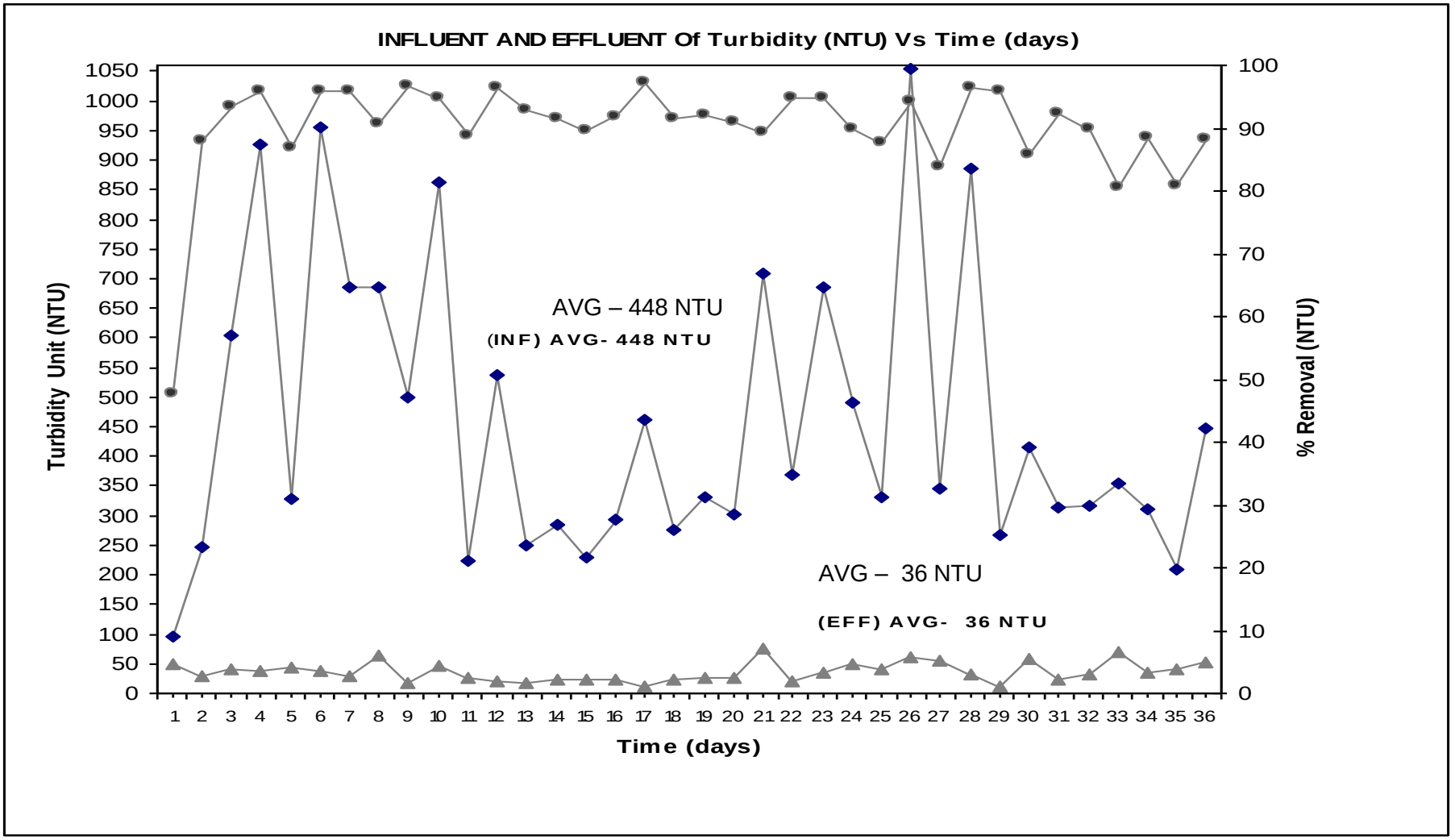
Oil & Grease REMOVAL

Monitoring of the influent and effluent Oil & Grease concentrations



TURBIDITY REMOVAL

Monitoring of the influent and effluent intense Turbidity (NTU)



- The total average removal efficiency for Turbidity 91% with in outlet concentrations 36 NTU.

Effluent
(Treated Wastewater)

Final effluent discaharged sufficiently met the target of effluent quality to standard B of DOE requirements

CONCLUSION

❖ Based on this SUABF system, the attached microbial bio-film development influences greatly the reactor.

❖ The experimental study shown that ***Single-Stage Reactor*** of biological filter, an effluent with average levels of 41 mg/L BOD_{5} , 173 mg/L COD and 40 mg/L and TSS can be obtained.

❖ Shown ***great reduction of organic loads*** (91%) $BOD_{5,}$(88%) COD as well as (93%) TSS to meet existing effluent of Standard B as stated in Environmental Quality 2009, Standard B.

❖***Not excellence for Oil & Grease and Ammonia Nitrogen*** - high organic load and solid waste that originated from wastes during slaughtering activities such as blood and animal fats

❖ SUABF shown suitability of the system for local abattoirs usage and able to cater local needs.

RECOMMENDATION

Waste minimization strategy

✓ Reduces work and helps in better and faster cleaning of the place as well as reduction in water consumption (cost savings).

✓ Reductions in both the wastewater flow and effluent strength, so reducing the size and cost of any treatment facility.

✓ Reuse/conversion of by-products and wastes into other value added end products such as protein supplement in animal feed as well as an organic fertilizer.

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