Performance Evaluation of Sewage Treatment Plant using Moving Bed Biofilm Reactor : A Case Study

Siddharth Parashar
Post Graduate Student of Environmental Engineering, Jagannath University, Chaksu, Jaipur.
Prof.(Dr.) Bharat Nagar
Head of Civil Engineering Department, Jagannath University, Chaksu, Jaipur.

Abstract

Urbanization has lead to water depletion & greater demand of water reuse. Sewage Treatment Plant (STP) are in existence for long so that the excessive amounts contaminants from sewage get reduced greatly& the water is fruitfully reused. Sewage treatment helps in reducing the burden on water bodies and reduces the degradation of water quality by ensuring that water use in done in appropriate manner like irrigation & flushing toilets. This study was conducted in a Sewage Treatment Plant in Mahima Panorma, Jagatpura, Jaipur. The performance & evaluation of this plant was never done long after its commissioning. The management was keen on doing this study as it will help them analyze the quality of parameters and the efficiency of this plant. The plant has a Moving Bed Bio-Film Reactor (MBBR) which is responsible for the activated sludge process which is the heart of the entire operation. The microorganisms which cause the decomposition stick as a bio-film to the medium. Parameters such as pH, BOD, COD, Oil & grease & TSS were evaluated to analyze the efficiency of this plant. The study would prove beneficial to the management of Mahima Panorama in assessing the efficiency of the existing equipment & expanding the existing plant capacity or operations for better results.This plan also defines the performance measurement plan taken up by this group which would be based on the aforementioned parameters.

I. INTRODUTION

The water in urban areas comes from wells, boring wells, streams & rivers. About 80% is recycled back as wastewater in different forms like bathing water, kitchen waste, washing clothes, washing cars,etc. Wastewater generated at such large rate wreaks havoc on the groundwater table as it gets accumulated in low lying areas. Sewage treatment plants not only help in reuse the water but also make the water free of the unpleasantness associated with sewage like color, odor& aesthetic appeal. Sewage treatment plant divides the sewage into sludge which is semisolid & a waste stream which can be used back in the environment safely. The purpose of this study is to assess whether the plant is working properly with Moving Bed Biofilm Bioreactor (MBBR) being at the centre of all the operations. Recommendations would be sent to the authorities so that proper measures would be taken to improve the performance of the plant.

Moving bed biofilm reactor is a pioneering effort in the activated sludge process part of the water treatment process. MBBRs require less space and are compact in comparison to its contemporaries like trickling filter and rotating biological contactor. The biggest advantage of the MBBR system is that it does not require require recycling saving the owner the pumping cost.

II. OBJECTIVE OF THE STUDY

The basic intention behind this study is:

- study important parameters like pH, BOD, COD, Oil & grease, lead, colour, odour& TSS which indicate the removal ability of the plant.
- evaluate the removal efficiency of the plant & nature of sewage after its treatment using moving bed biofilm reactor.
- deciding whether an expasion in the plant equipment is needed to improve its efficiency.

III. DETAIL OF MOVING BED BIOFILM REACTOR (MBBR)

Moving bed biofilm reactor (MBBR) was a wastewater treatment process invented by Prof.

Hallvard Odegaard at Norweign University in the late 1980s.

The process contains an aeration tank, similar to an activated sludge tank with plastic carriers which provide large surface area for the biofilm to grow on them. The carriers are made up of high density polyethylene (HDPE). The carriers and the aerators help intermixing of the sludge in a highly fluidized state. A sieve is provided for the carriers to keep the carriers in the tank itself.

The MBBR arrangement is better than other activated sludge arrangements as it is compact and can deal with shock loads easily. They also do not need any recycling. MBBRs can be incorporated as retrofitting to improve expansion as they easily adapt to improve the capacity and efficiency of the plant. The filing degree in the beginning can be kept up to 40% and can be gradually increased to 70% as per requirement.

Other advantages include: higher sludge retention time (SRT), lower sludge production, no requirement of a secondary clarifier as its performance remains independent of it.

The only disadvantage is it is prone to clogging and head loss due to buildup.

IV. DISCUSSION ABOUT IMPORTANT PARAMETERS

A) pH

pH is the measure of the hydrogen ion (H+). pH is the most important parameter in evaluating the nature of sewage. It is highly acidic in the beginning, when the sewage is fresh during the supply from the source. Gradually, it decreases and the sewage becomes more basic after it has mixed with other streams. The decomposition of sewage also lowers the pH after a while. Generally the pH has been found to be around 5.5-9.0.pH is measured using a pH meter.

B) Biochemical Oxygen Demand (BOD)

It is the measure of oxygen required to oxidize the organic matter through the help of microorganisms present in the sample. It is one of the most important parameter for samples of wastewater & surface water. BOD tests indicate:

1) determination of approximate quality of oxygen required for biological stabilization of organic matter.
2) measurement of efficiency of a treatment process.
3) determination of sewage strength.
4) amount of clear water required for efficient disposal of wastewater using the dilution process.

The organic matter present in wastewater may belong to two groups:

- Carbonaceous matter
- Nitrogenous matter

The ultimate carbonaceous BOD of a liquid is the amount required to oxidize the carbonaceous materials which is subject to microbial decomposition. It is the first stage of oxidation. The following oxidation of nitrogenous material is called the second stage. BOD is a slow process & takes a long to fructify. Generally, a 5 day period is necessary for a standard BOD test, during which 60-70% of the entire process gets completed. While it takes around 20 days for the process to complete 95-99% processes involved in it.

C) Chemical Oxygen Demand (COD)

Since the BOD test takes around 5 days to fructify, another alternative test exists called Chemical Oxygen Demand (COD) which can measure the content of organic matter of both wastewater and natural water. The COD test requires not more than 3 hours for determination of results. COD tests are more suitable for measuring the organic matter present in industrial wastes which are highly toxic to living beings. COD test values are higher as compared to BOD test as they take into consideration fats and lignin which take a while to oxidize. Potassium dichromate, a strong oxidising agent is used to oxidize & titrate the sewage sample.

D) Oil and Grease

Oil & grease is an important parameter which needs to be measurement owing to its prescence in kitchen waste. Oils and grease are carried out by ASTM methods using dilute Hydrochloric Acid.

E) Total Suspended Solids

Total suspended solids need to be removed as they give a dirty look to the water sample. Total suspended solidsare calculated by filtering the sewage sample in a Imhoff cone.

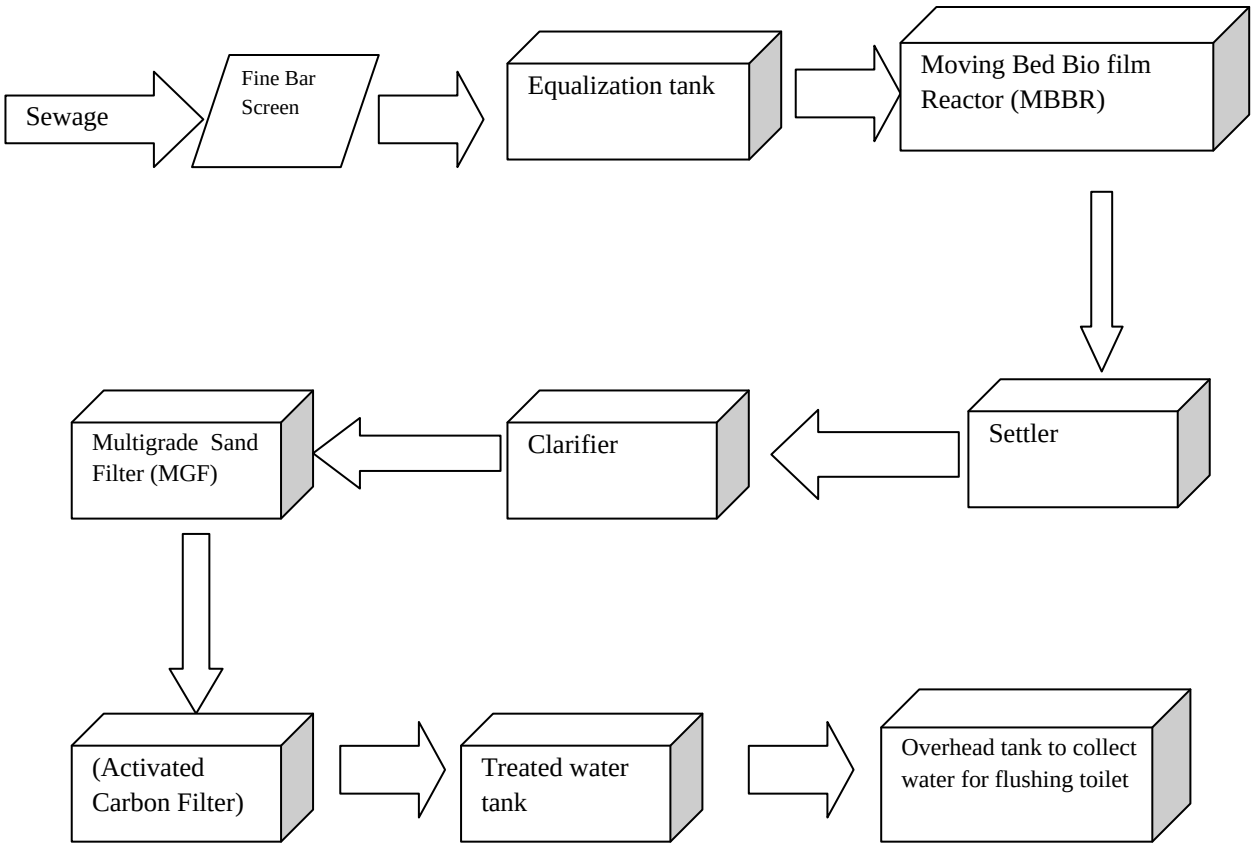
F) Lead

Lead being a carcinogen is washed off into the sewage sample as a result of painting in buildings.

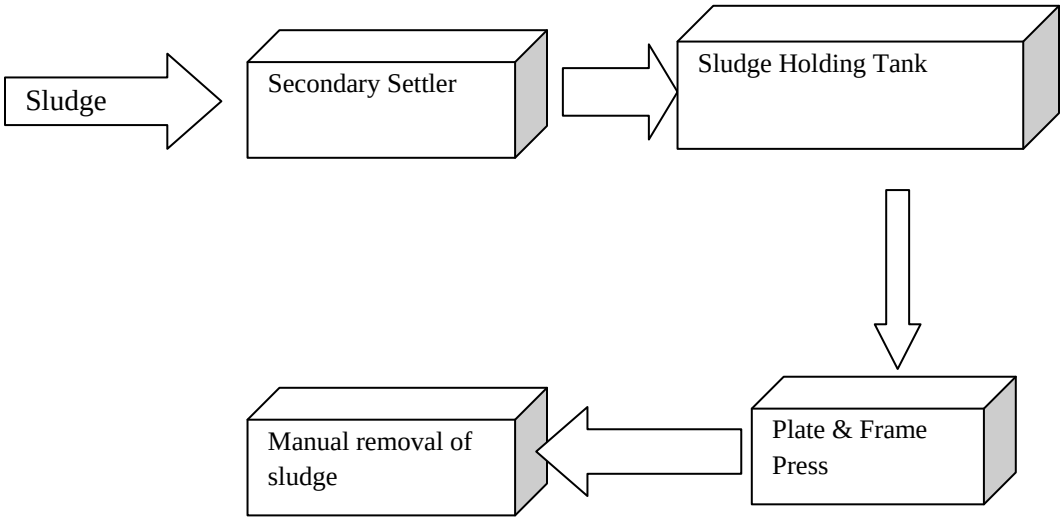
G) Color& Odor

Color & odor affect the aesthetics of water sample, hence need to be removed.

Pathway of Water:



Pathway of Sewage:



V. METHODOLOGY

Currently the sewage treatment operations last for over 10 hours per day. The entire study was conducted over a period of 20 days in the month of November to December, 2017 . Samples were collected from the sewage inlet and the treated water outlet in a one litre bottle each . The testing of samples was done in a government approved laboratory by the name Team Test House, Sitapura, Jaipur. Samples were made to undergo the following tests: pH, BOD, COD, Oil and grease & total suspended solids.

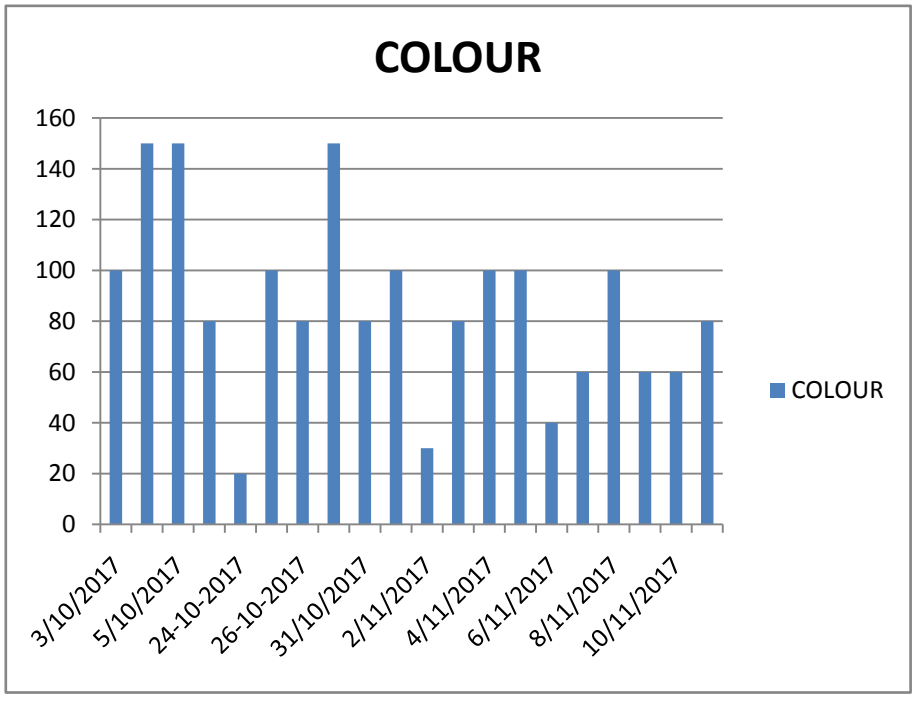
VI. WATER STANDARDS

The standards for discharge of Environmental Pollutants, Part A: Effluents as per Schedule VI of the Environmental (Protection) Rules 1986 & National River Conservation Directorate for Faecal Coliforms (Values in mg/lit unless stated) are:

Sr.No.	Characterstics	Public Sewers (Values in mg/lit unless stated)
1	Colour	All effort needs to be made to remove colour
2	Odour	All effort needs to be made to remove odour
3	pH	Between 5.5 to 9.0
4	Temperature	Should not exceed 5°C above receiving water temperature.
5	Biochemical Oxygen Demand (BOD)	350
6	Chemical Oxygen Demand (COD)	250
7	Total Suspended Solids (TSS)	600
8	Lead	1.0
9	Oil & Grease	20

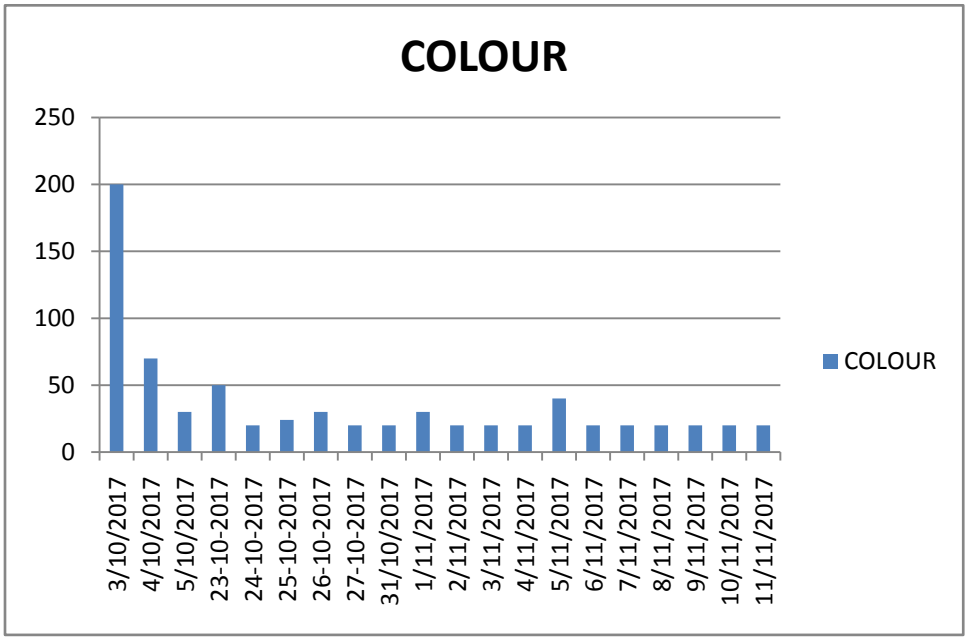
Inlet

DATE	COLOUR
3/10/2017	100
4/10/2017	150
5/10/2017	150
23-10-2017	80
24-10-2017	20
25-10-2017	100
26-10-2017	80
27-10-2017	150
31/10/2017	80
1/11/2017	100
2/11/2017	30
3/11/2017	80
4/11/2017	100
5/11/2017	100
6/11/2017	40
7/11/2017	60
8/11/2017	100
9/11/2017	60
10/11/2017	60
11/11/2017	80



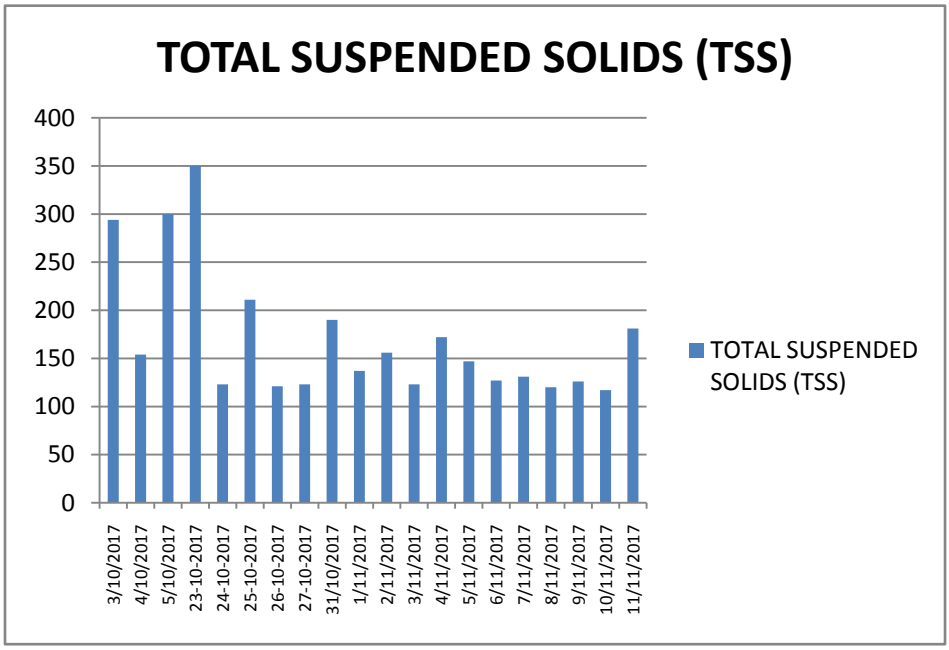
Outlet

DATE	COLOUR
3/10/2017	200
4/10/2017	70
5/10/2017	30
23-10-2017	50
24-10-2017	20
25-10-2017	24
26-10-2017	30
27-10-2017	20
31/10/2017	20
1/11/2017	30
2/11/2017	20
3/11/2017	20
4/11/2017	20
5/11/2017	40
6/11/2017	20
7/11/2017	20
8/11/2017	20
9/11/2017	20
10/11/2017	20
11/11/2017	20



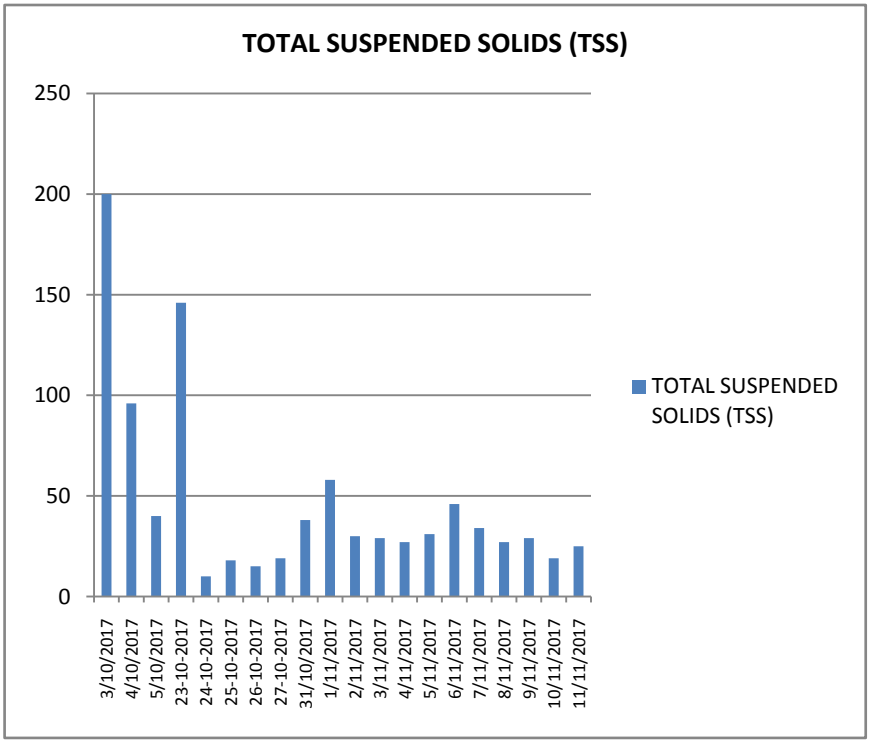
Inlet

DATE	TOTAL SUSPENDED SOLIDS (TSS)
3/10/2017	294
4/10/2017	154
5/10/2017	300
23-10-2017	350
24-10-2017	123
25-10-2017	211
26-10-2017	121
27-10-2017	123
31/10/2017	190
1/11/2017	137
2/11/2017	156
3/11/2017	123
4/11/2017	172
5/11/2017	147
6/11/2017	127
7/11/2017	131
8/11/2017	120
9/11/2017	126
10/11/2017	117
11/11/2017	181



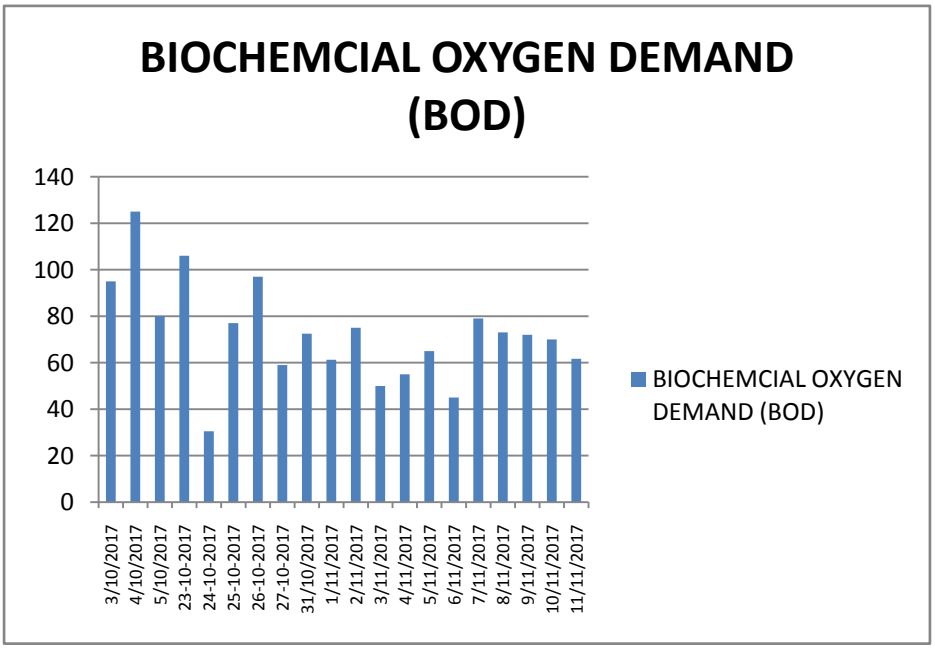
Outlet

DATE	TOTAL SUSPENDED SOLIDS (TSS)
3/10/2017	200
4/10/2017	96
5/10/2017	40
23-10-2017	146
24-10-2017	10
25-10-2017	18
26-10-2017	15
27-10-2017	19
31/10/2017	38
1/11/2017	58
2/11/2017	30
3/11/2017	29
4/11/2017	27
5/11/2017	31
6/11/2017	46
7/11/2017	34
8/11/2017	27
9/11/2017	29
10/11/2017	19
11/11/2017	25



Inlet

DATE	BIOCHEMCIAL OXYGEN DEMAND (BOD)
3/10/2017	95
4/10/2017	125
5/10/2017	80
23-10-2017	106
24-10-2017	30.5
25-10-2017	77
26-10-2017	97
27-10-2017	59
31/10/2017	72.5
1/11/2017	61.25
2/11/2017	75
3/11/2017	50
4/11/2017	55
5/11/2017	65
6/11/2017	45
7/11/2017	79
8/11/2017	73
9/11/2017	72
10/11/2017	70
11/11/2017	61.67



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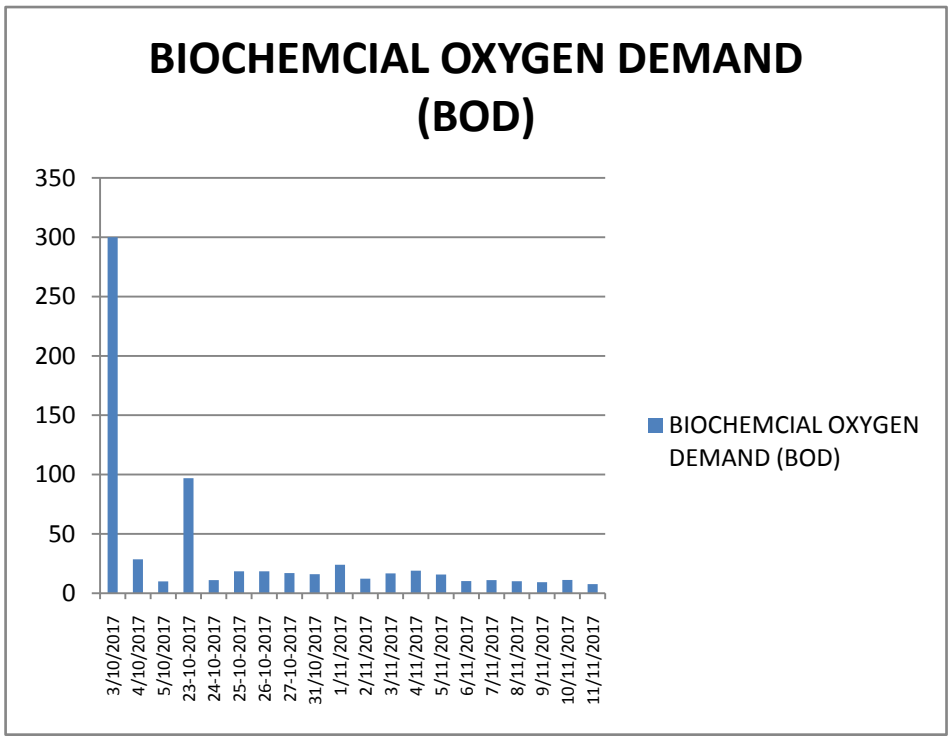
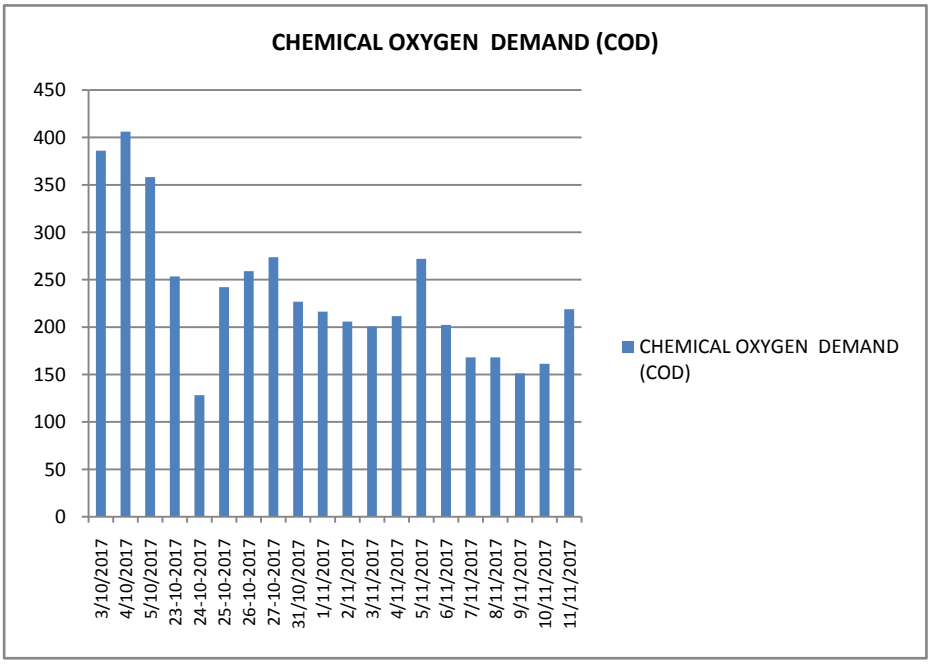
DATE	BIOCHEMCIAL OXYGEN DEMAND (BOD)
3/10/2017	300
4/10/2017	28.57
5/10/2017	10
23-10-2017	97
24-10-2017	11
25-10-2017	18.5
26-10-2017	18.5
27-10-2017	17
31/10/2017	16
1/11/2017	24
2/11/2017	12.33
3/11/2017	16.67
4/11/2017	19
5/11/2017	15.75
6/11/2017	10.23
7/11/2017	11
8/11/2017	10.17
9/11/2017	9.25
10/11/2017	11.17
11/11/2017	7.75



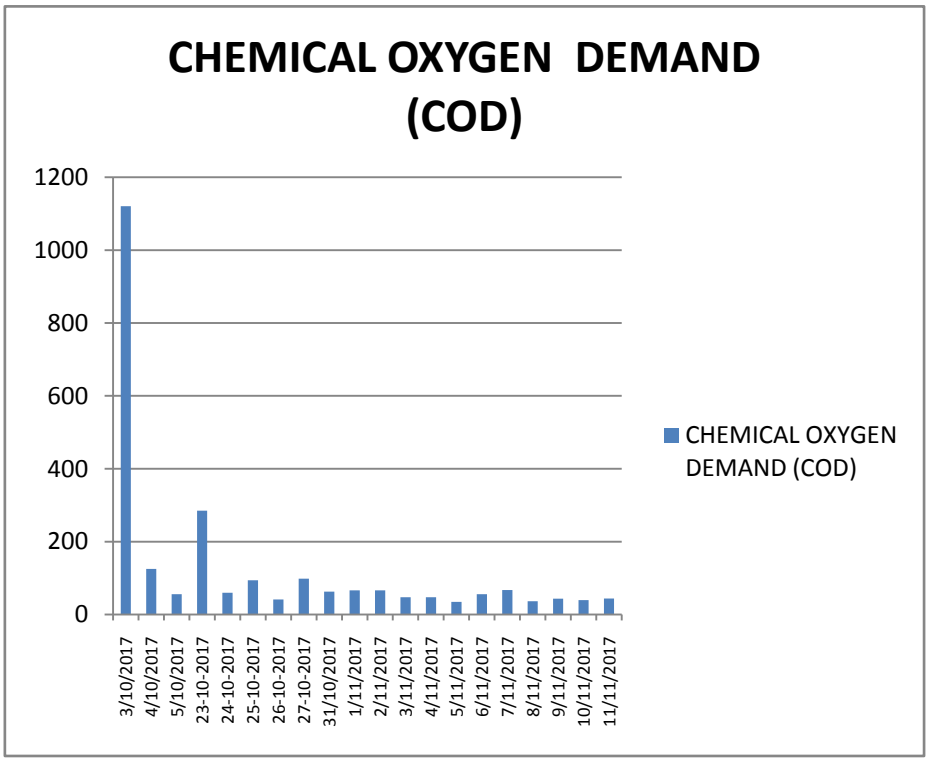
Inket

DATE	CHEMICAL OXYGEN DEMAND (COD)
3/10/2017	386.03
4/10/2017	406.08
5/10/2017	358.19
23-10-2017	253.47
24-10-2017	128.16
25-10-2017	242.08
26-10-2017	259.01
27-10-2017	273.6
31/10/2017	226.72
1/11/2017	216.26
2/11/2017	205.79
3/11/2017	200.64
4/11/2017	211.58
5/11/2017	272.06
6/11/2017	202.3
7/11/2017	168
8/11/2017	168
9/11/2017	151.2
10/11/2017	161.28
11/11/2017	218.88



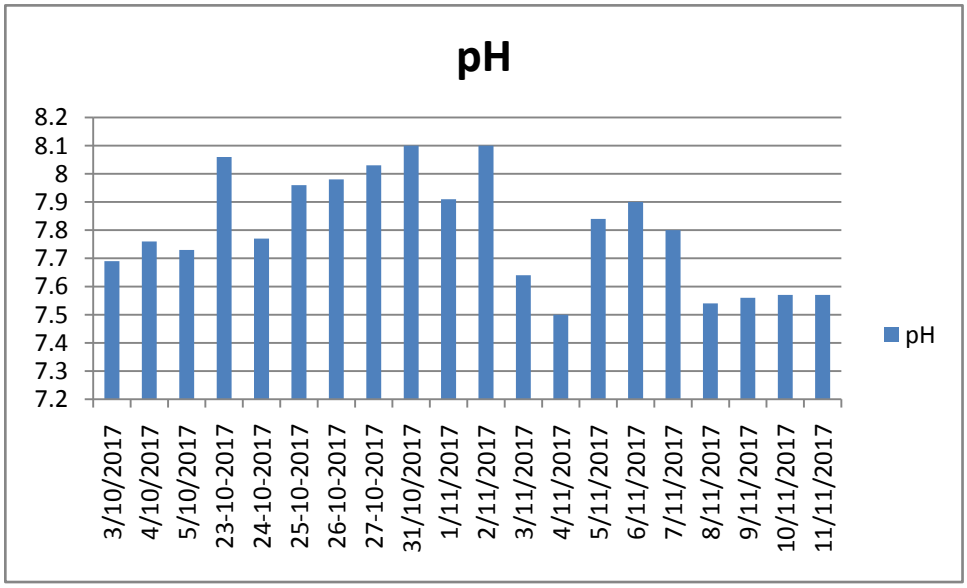
Outlet

DATE	CHEMICAL OXYGEN DEMAND (COD)
3/10/2017	1120.48
4/10/2017	125.33
5/10/2017	55.94
23-10-2017	284.8
24-10-2017	59.81
25-10-2017	93.98
26-10-2017	41.47
27-10-2017	98.5
31/10/2017	62.78
1/11/2017	66.27
2/11/2017	66.27
3/11/2017	47.42
4/11/2017	47.42
5/11/2017	34.88
6/11/2017	55.81
7/11/2017	67.2
8/11/2017	36.48
9/11/2017	43.68
10/11/2017	39.42
11/11/2017	43.78



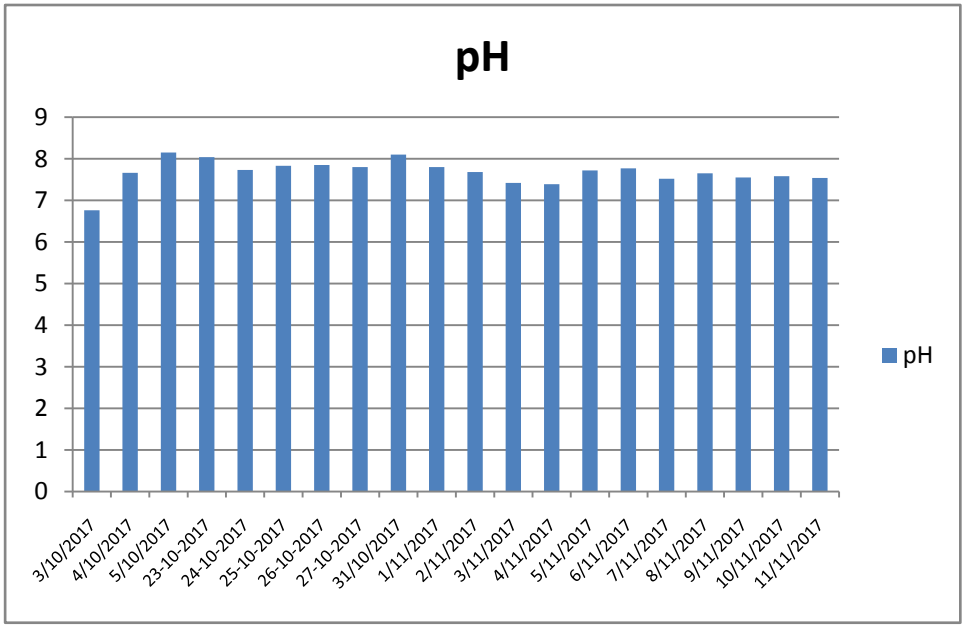
Inlet

DATE	pH
3/10/2017	7.69
4/10/2017	7.76
5/10/2017	7.73
23-10-2017	8.06
24-10-2017	7.77
25-10-2017	7.96
26-10-2017	7.98
27-10-2017	8.03
31/10/2017	8.1
1/11/2017	7.91
2/11/2017	8.1
3/11/2017	7.64
4/11/2017	7.5
5/11/2017	7.84
6/11/2017	7.9
7/11/2017	7.8
8/11/2017	7.54
9/11/2017	7.56
10/11/2017	7.57
11/11/2017	7.57



Outlet

DATE	pH
3/10/2017	6.76
4/10/2017	7.66
5/10/2017	8.15
23-10-2017	8.04
24-10-2017	7.73
25-10-2017	7.83
26-10-2017	7.85
27-10-2017	7.8
31/10/2017	8.1
1/11/2017	7.8
2/11/2017	7.68
3/11/2017	7.42
4/11/2017	7.39
5/11/2017	7.72
6/11/2017	7.77
7/11/2017	7.52
8/11/2017	7.65
9/11/2017	7.55
10/11/2017	7.58
11/11/2017	7.54



Inlet

DATE	OIL & GREASE
3/10/2017	16
4/10/2017	17
5/10/2017	44
23-10-2017	10
24-10-2017	4
25-10-2017	17
26-10-2017	28
27-10-2017	30
31/10/2017	30
1/11/2017	8
2/11/2017	27
3/11/2017	7
4/11/2017	10
5/11/2017	26
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7/11/2017	7
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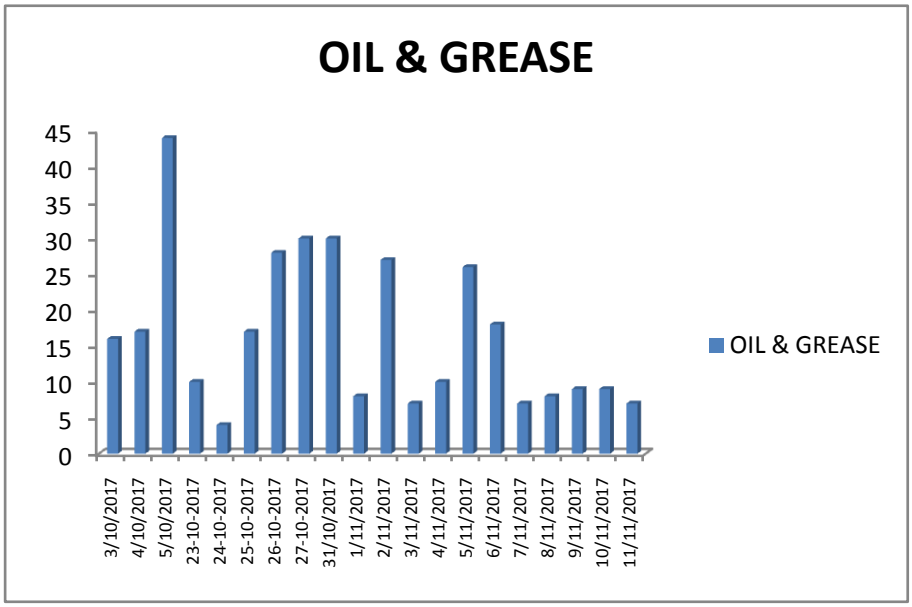
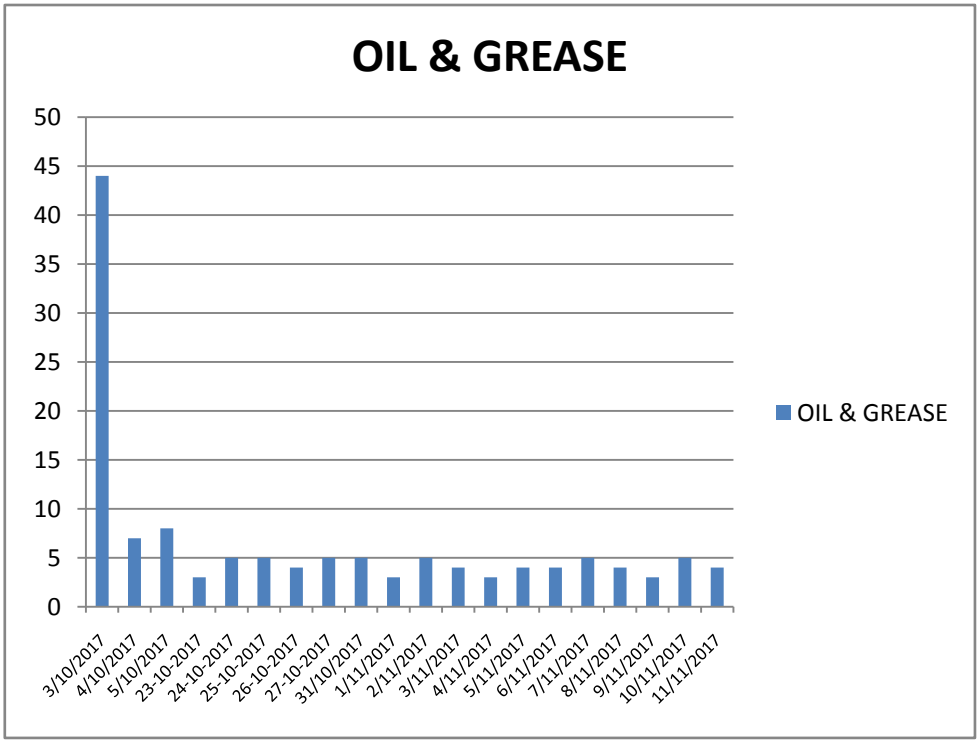
9/11/2017	9
10/11/2017	9
11/11/2017	7



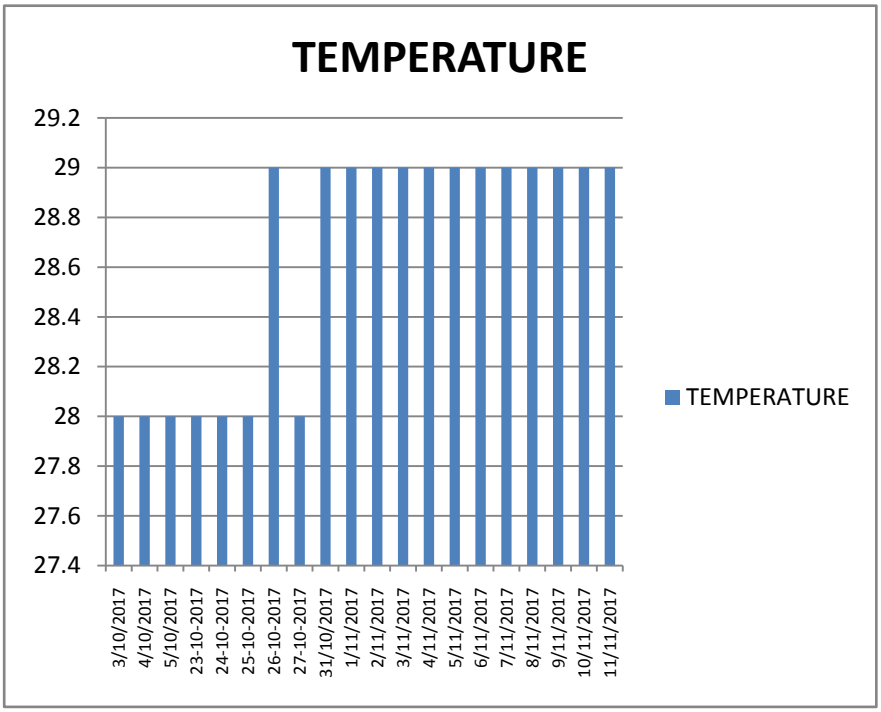
Outlet

DATE	OIL & GREASE
3/10/2017	44
4/10/2017	7
5/10/2017	8
23-10-2017	3
24-10-2017	5
25-10-2017	5
26-10-2017	4
27-10-2017	5
31/10/2017	5
1/11/2017	3
2/11/2017	5
3/11/2017	4
4/11/2017	3
5/11/2017	4
6/11/2017	4
7/11/2017	5
8/11/2017	4
9/11/2017	3
10/11/2017	5
11/11/2017	4



Inlet

DATE	TEMPERATURE
3/10/2017	28
4/10/2017	28
5/10/2017	28
23-10-2017	28
24-10-2017	28
25-10-2017	28
26-10-2017	29
27-10-2017	28
31/10/2017	29
1/11/2017	29
2/11/2017	29
3/11/2017	29
4/11/2017	29
5/11/2017	29
6/11/2017	29
7/11/2017	29
8/11/2017	29
9/11/2017	29
10/11/2017	29
11/11/2017	29



Outlet

DATE	TEMPERATURE
3/10/2017	28
4/10/2017	28
5/10/2017	28
23-10-2017	29
24-10-2017	28
25-10-2017	28
26-10-2017	28
27-10-2017	28
31/10/2017	29
1/11/2017	29
2/11/2017	28
3/11/2017	29
4/11/2017	29
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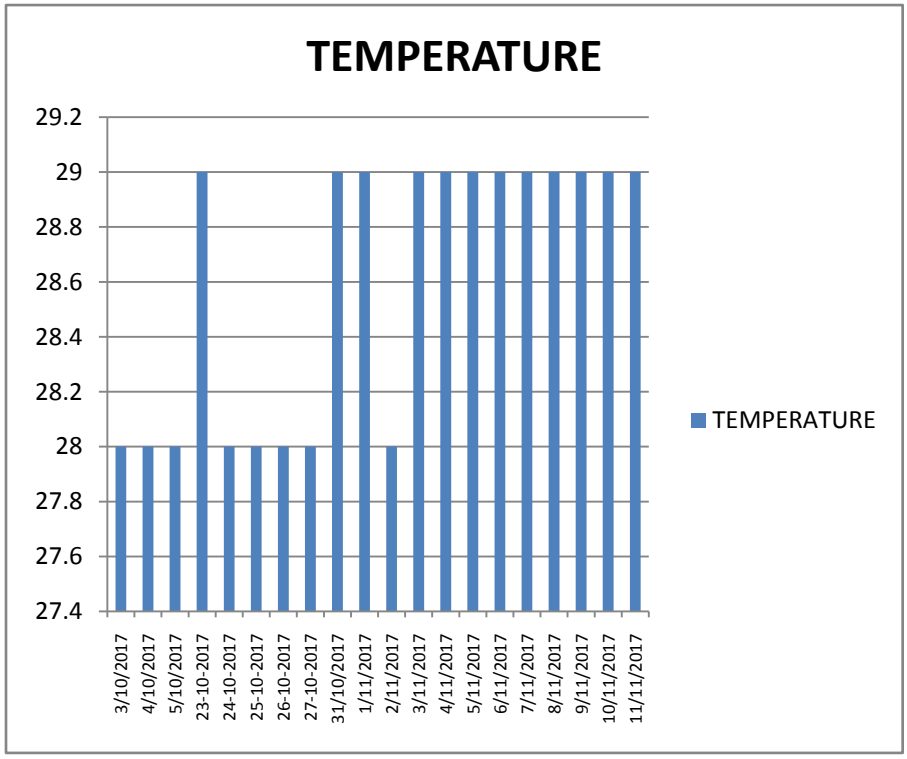


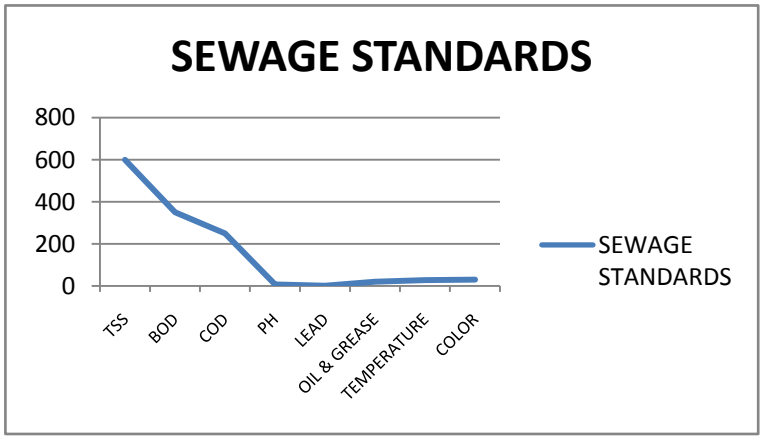
A) Removal Efficiency

PARAMETER	AVERAGE VALUES	REMOVAL EFFICIENCY IN %
TSS		
INLET	**170.15**	**79.02**
OUTLET	**35.7**	
BOD		
INLET	**72.44**	**54.18**
OUTLET	**33.19**	
COD		
INLET	**235.46**	**47.09**
OUTLET	**124.58**	
PH		
INLET	**7.8**	**1.67**
OUTLET	**7.67**	

OIL & GREASE		
INLET	**16.6**	**60.84**
OUTLET	**6.5**	
TEMP		
INLET	**28.65**	**0.17**
OUTLET	**28.6**	
COLOUR		
INLET	**86**	**58.49**
OUTLET	**35.7**	

B) Standards Graph

PARAMETERS	SEWAGE STANDARDS
TSS	600
BOD	350
COD	250
PH	7
LEAD	1
OIL & GREASE	20
TEMPERATURE	28
COLOR	30



VII. RESULT DISCUSSION

The removal efficiency of the Sewage Treatment Plant was found to be satisfactory. Same could be said about results of all the eight parameters: BOD, COD, TSS, Color, Odor, Temperature, pH, oil & grease. The plant has been efficiently reusing the sewage as manure & the water is recycled back for flushing toilets.

VIII. RECOMMENDATIONS

1. Moving Bed Biofilm Bioreactor needs to be scraped off regularly as it is prone to scrapping.
2. Testing of samples, like this study needs to be carried out often, so that the efficiency & efficacy of the treatment plant remains common knowledge.

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