Operational Challenges of Sewage Treatment Plants in Hilly Cold Climate: A Case Study of Shimla, India

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ABSTRACT

The underperforming treatment plants are pathways for transmission of infectious disease like Hepatitis E Viruses (HEV) which poses global health threat. The sewage treatment plant situated in hilly and cold climate of Shimla was underperforming which caused various episode of HEV induced jaundice outbreak thus in this research performance evaluation an efficient tool is used to identify the operational challenges of sewage treatment. The stratified sampling is used to determine the physiochemical parameters of inflow-outflow of each process to assess the performance of sewage treatment. The overall removal efficiency of Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD_5) and Total Suspended Solids (TSS) are found to be 82%, 75% and 79% respectively which was lowered by 10 to 15% during winter season. Topographical undulation and flow variation might be the reason of shock load and significantly high flow velocity. High strength sewage and lowered bioactivity during cold weather has caused poor quality effluent which might be enhanced by optimal dosage of alum in clariflocculator. Virus load test and optimum disinfection of effluent may restrict viruses to cause disease outbreak. Present research indicates that similar field study can achieve the social sanitation and conservation of river in developing countries.

Keyword: performance evaluation, sewage treatment plant, operational challenges, physiochemical parameter, stratified sampling, removal efficiency.

1.0 INTRODUCTION

Wastewater engineering is a well-established field although performance of sewage treatment plant based on meticulously tested technology faces operational challenges at grass root level. Performance of pilot plant and actual in situ treatment plant usually falls apart especially in developing country in spite of the fact that both have same working principle. Major challenges ascribed to underperforming sewage treatment facilities are lack of assurance and disoriented decision making by the administrator of municipal authority (Al-Sa'ed & Tomaleh 2012). Effluent of sewage treatment plant are major carriers of pathogen into discharge water bodies and raw water sources (Monedero *et al.* 2018). Performance of every STP varies greatly even their working principle and technology is same (Hasan *et al.* 2019). That has been palpable by the fact that in India 659 towns are located on the bank of 317 identified severely polluted river sections of 275 rivers (CPCB 2018). Polluted river sections creates threat to critical as well as chronic public health and hygiene issues. Untreated or partially treated sewage may cause stress to public health conditions (Chatterjee *et al.* 2016).

The major problems concomitant with sewage treatment are designed capacity of plant is less than that of sewage generated, sewage collection network capacity is less than the treatment plant capacity and most important floundering sewage treatment plants. The underperforming treatment plant are pathways for transmission of infectious disease like Hepatitis E Viruses (HEV) which poses global health threat (Schaeffer *et al.* 2018). Khuroo *et al.* (2016) swotted the epidemics of HEV and found that this fecal-oral route transmissible disease can develop into epidemics in few weeks. Infected individuals excrete the HEV through their stools and vomitus at high concentrations in sewage water. Asymptomatic people may also shed large amount of viral particles through their stools in sewage (Sano *et al.* 2016; Schaeffer et. al. 2018). Microorganism are widely disseminated in surface water bodies through discharge of treated and untreated sewage (Kokkinos 2015). The water supply system become vulnerable to community and may cause immediate epidemics if virus infected water get mixed with raw water source.

Sewage generation in India is about 61754 MLD against the current treatment capacity of 22963 MLD as a result 62% of sewage found its pathway leading into the nearby inland water bodies without treatment (Kamble 2019). Disposal of sewage without treatment causes direct and indirect exasperation for ecology and biodiversity in the river. There are 193 CETPs and 920 STPs operating in India (MoEF&CC 2016) and performance evaluation of 195 STPs out have these had been carried out by CPCB and sponsored by Ministry of Environment, forest and Climate Change Government of India under National River Conservation Plan (CPCB 2013). The study report comprises of performance evaluation information of sewage treatment plant constructed under the various national and state level river action plan. The data represents that out of total 152 STPs, 30 are not operative, 28 are under performance, 49 have surpassed BOD discharge limit and 7 surpassed COD discharge limit (CPCB 2013). Treatment plants which are neither assessed under National River Conservation Plan (NRCP) nor evaluated by operating agencies or eluded due to lack of, resources, expertise and funds. STPs incapable to treat the sewage to a anticipated level due to faulty design, operational challenges, slackness, power shortage and rare maintenance and inferior technology (CPCB 2013).

Performance evaluation is an impressive tool to answer the question “weather the any system is serving its envisioned purpose economically and efficiently or not?” The impact of effluent on receiving body and ecology can be assessed by performance evaluation of STPs. Products outcome of performance evaluation are elementary information for planning and design for installation of new sewage treatment facility or retrofitting, enhancement and extension of existing STPs. Performance evaluation is a incessant process which augments the whole installation and operation of STPs to achieve greater of efficiency and economy.

Sewage treatment plants be made up of sequential process through which sewage or wastewater flows and get treated before discharge. Wastewater treatment plants are usually categorised based on diversity of technologies. The technologies are mainly classified as natural, conventional, modified and advanced technology of treatment. The methodology of performance evaluation remains similar for all types of treatment technology but the testing parameters and operational parameters are technology dependent (Metcalf & Eddy 2003). Performance evaluation of STPs situated in hilly zone have not got much admiration. It has been observed through literature review that effect of low temperature over efficiency of STPs had required much more attention of researcher. In developed countries, wastewater treatment plants are fully based on system automation, sensors and supervisory control and data acquisition (SCADA) system which collects data on real time basis thus performance evaluation is much easier task. In developing country as India where maximum of plants are manually operated and be governed by manual laboratory data, performance evaluation remain as burdensome, time taking and expensive affair.

The present study aims to determine the operational challenges faced by sewage treatment plant located in a hilly, cold and cloudy climate of Shimla by using performance evaluation as a tool. The study may be helpful in avoiding the risk of jaundice outbreak due to Hepatitis E or any other virus spreading through fecal-oral route in the city. Main objective of this research is to evaluate the effect of temperature and hilly terrain in terms of sewage characteristics, operational parameter and efficiency of the sewage treatment plant.

2.0 Study Area and Status of Sewage Treatment

The present research have addressed the HEV epidemics occurred in Shimla a class I city of India and capital of Himachal Pradesh. Shimla was designated summer capital of British era India before independence (CSE 2011). The city is a hill station located on the slanting spur of the central Himalaya range. Planning commission of India demarcated and classified Shimla as a hilly town with average slope of 30 percent. Climate of Shimla is predominantly cold and cloudy. The average temperature varies 15-25˚C in summer and 0-13˚C in winter. The city records average rainfall of 900 mm and snow fall occurs in last week of December. According to Municipal Corporation Shimla, over-all profile of the regular floating population is approx. 75000 and permanent population is around 1,69,758 within the municipal corporation area. Total urban population can be accounted as 2,01,500 (MC Shimla 2011). Shimla is one of the desired destination for domestic and foreign tourists. Shimla accommodates large number of visitors during summer as well as from Christmas to New Year. The sewage networks of Shimla is too old and not sufficient to accommodate the urban population and floating tourist population. In 2005, expansion work for sewage network was initiated and new sewers were laid, along this six new decentralised sewage treatment plants were also constructed. The six treatment plants constitute total installed capacity of 35.63 MLD and total length of the sewer network was 220.6 km (CSE 2011 and MC Shimla 2011). The major sewage treatment plant of Shimla were underperforming and faced operational challenges which was purview of this research. The critical situation had raised up the threat to public hygiene and caused severe episodes of jaundice outbreak in 2007 and 2010 (CSE 2011 and MC Shimla 2011). The recent lethal jaundice outbreak epidemic of 2015-16 had affected more than ten thousand people and few fatality. The fig. 1 shows the location of Shimla city and HEV affected area. The epidemic had occurred due to underachieving Sanjjauli Maliana STP which effluent was found its pathway into Ashwini Khad stream. Ashwini Khad is an inland surface raw water source for Ashwini Khad water treatment plant which is positioned in the downstream of Sanjauli Maliana STP.

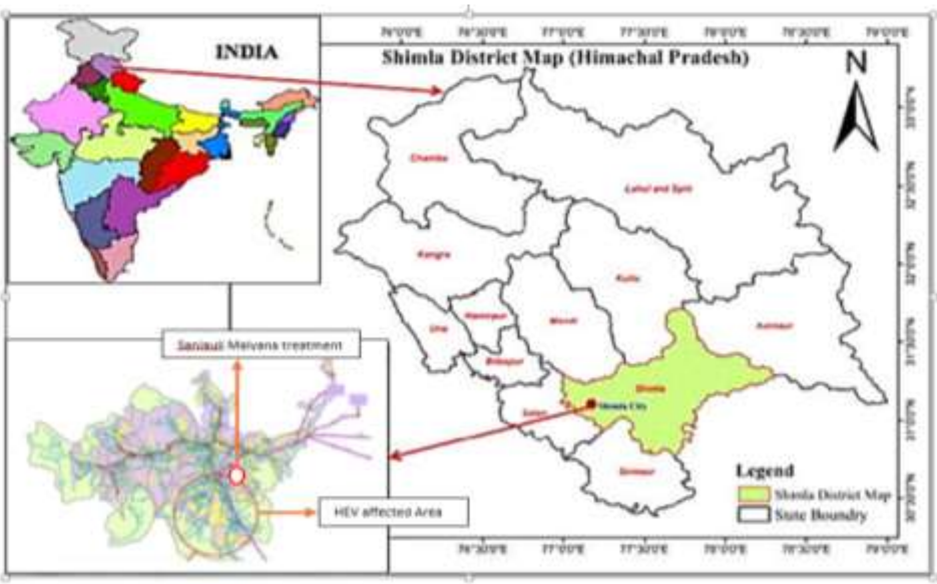
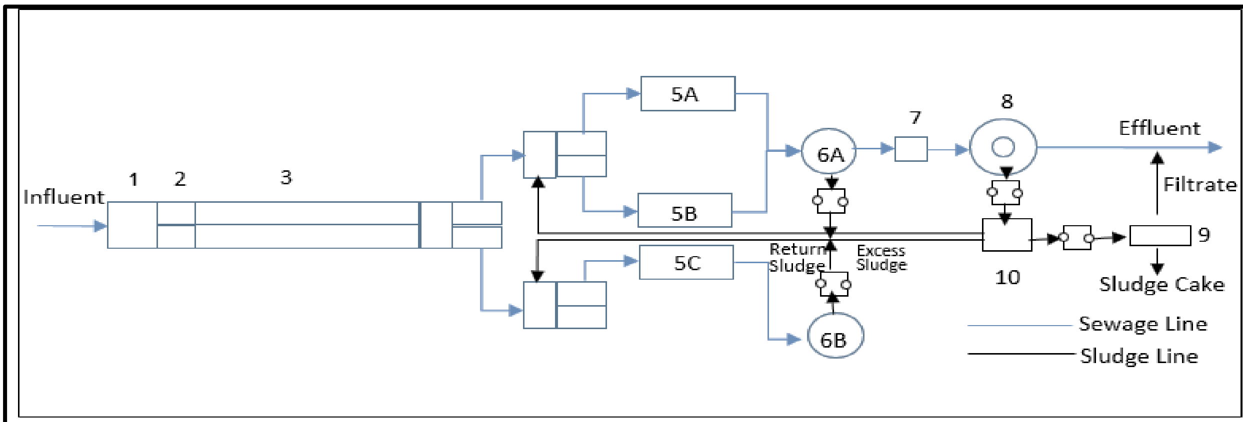


Fig. 1 Location of study area and Sanjauli Malyana Sewage Treatment Plant

2.1 Design and Construction of Sewage Treatment Plant

The current study has taken Sanjauli Malyana STP to apply the performance evaluation tool in such a mean that operational challenges can be addressed in order to lessen the risk of the episodes of jaundice outbreak. The fig. 1 shows the location of Sanjauli Malyana STP. The sewage treatment plant has designed capacity of 4.44 MLD and operated under the esteemed supervision of engineers and managers of Himachal Pradesh Irrigation and Public Health (HPIPH) Department of city Shimla and Municipal Corporation Shimla. Sanjauli Malyana STP is based on extended aeration activated sludge process followed by physiochemical process of coagulation and flocculation. Screens and grit are provided for pre-treatment of sewage. Filter press and sludge drying beds are provided for sludge handling and disposal. All the treatment process and flow diagram is indicated in fig. 2.



No.	Name	Size	No.	Name	Size
1	Inlet tank	2.65 m X 1.45 m X 1.2 m SWD	6A	Secondary Clarifier	16.9 m Dia. X 3 m SWD
2	Screen	5.0 m X 0.7 m X 0.4 m SWD	6B	Secondary Clarifier	16.9 m Dia. X 3 m SWD
3	Grit Chamber	13.75 m X 1 m X 0.5 m SWD	7	Flash Mixer	1.25 m X 1.25 m X 2 m SWD
4	Distribution Box		8	Clariflocculator	18.55 m Dia. X 2.5 m SWD
5A	Aeration Tank	13.35 m X 26.7 m X 3.6 m SWD	9	Filter Press	
5B	Aeration Tank	13.35 m X 26.7 m X 3.6 m SWD	10	Sludge Well	
5C	Aeration Tank	13.35 m X 26.7 m X 3.6 m SWD			

Fig. 2 Flow diagram of Sanjauli Malyana Sewage Treatment Plant

3.0 MATERIALS AND METHODS

3.1 Data collection

The data collection was done in the winter season in order to study the effect of low temperature and cloudy weather of Shimla on performance of sewage treatment plant. Author took utmost care to obtain the representative sample as well as to reduce the error in the testing and analysis.

3.2 Sampling techniques

Stratified Random Sampling method had selected with two stratum viz. temporal strata consist of Daily, weekly, monthly and seasonal variation and spatial strata comprised of variation of location. The stratified sampling was reported appropriate for performance evaluation of sewage treatment plant by Zhang (2007). By assessing an inclusive standard deviation (standard deviation generated in total after sampling and analysis) the essential number of samples for a water sampling may be projected to obtain a reliable statistical results (APHA 2012).

3.3 Physiochemical Parameters

Physiochemical parameters of sewage are major indicators to evaluate the performance of sewage treatment plant. . Hourly inflow variation to the plant was studied to visualise flow fluctuation pattern. Flow velocity through screen and grit chamber were measured and compared with their design value using t-test. Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD) selected to evaluate the Influent and effluent characteristics as well as degree of treatment in each process and overall STP. These parameter were found most suitable to carry performance evaluation of STP (CPCB 2013; Chatterjee *et al.* 2016; Okubo *et al.* 2016; Von Sperling *et al.* 2001). Operational parameter of biological process was determined in terms of mixed liquor suspended solid (MLSS), mixed liquor volatile suspended solid (MLVSS) and sludge volume index (SVI). Temperature was taken as control parameter to study the effect of winter season over the efficiency of plant and operational parameters. Jar test was conducted to determine the performance of the physiochemical process that is coagulation and flocculation installed in the STP as polishing unit. Most probable number (MPN) test was performed to evaluate the total coliform in effluent sample just before the discharge into the stream. Sludge wasted from extended aeration process was allowed to stabilise through aeration inside the laboratory. Aerators are used to provide aeration and reduction of biomass and moisture is monitored regularly until constant VSS is observed. Similar study was performed by Özdemir *et al.* (2014) to determine stability of sludge obtained from extended aeration. Hourly power consumption was compared with hourly flow variation of STP to evaluate the energy efficiency. The testing methodology is adopted as standardised by APHA (2012). Table 1 contains the testing methods employed to evaluate the sewage parameters. The laboratory test were performed inside the laboratory of the Sanjauli Malyana Treatment plant and environmental laboratory of CEEE, NIT Hamirpur.

Table 1 Parameters observed and their testing methods

Sl no.	Parameter	Testing methods
1	TSS/MLSS/MLVSS	Gravimetric Method
2	BOD_5	Winkler’s Method
3	COD	Closed reflux method
4	Settled Sludge Volume	Column Settling Method

5	Total Coliform	MPN

3.4 Data analysis and data validation

Statistical analysis were performed using IBM SPSS Statistics v21. Descriptive statistics were determined for the data maintained by establishment (laboratory logbook) and laboratory experimental results (experimental data set) obtained by the author. The data of laboratory log book register had been validated through relating it with experimental data set. Equal number of samples from laboratory log book and experimental data set were selected randomly for each parameter and both samples were compared using t-test.

4.0 RESULTS AND DISCUSSION

4.1 Flow characteristics

The average daily inflow for Sanjuali Maliana STP had observed to be 1.61 MLD and while it's designed capacity is 4.44 MLD. The fig. 3 shows hourly variation averaged over the monthly data , hourly variation averaged over the total six month data (Overall) and average daily inflow averaged over six month hourly data (Average). The inflow decreases more rapidly after midnight in winter season. In month of sepetember at Sanjauli Maliana plant there was a thunderstorm observed due to which interpreted by peak observed at 16:00 hrs in graph. Flow peak factor had found to be 2.8 compared to 2.5 designed value. The variation indicates the need of identification of all sources of raw sewage and their characteristic during dry and wet weather that are reaching to inlet as accentuated by Hasan et al 2019.

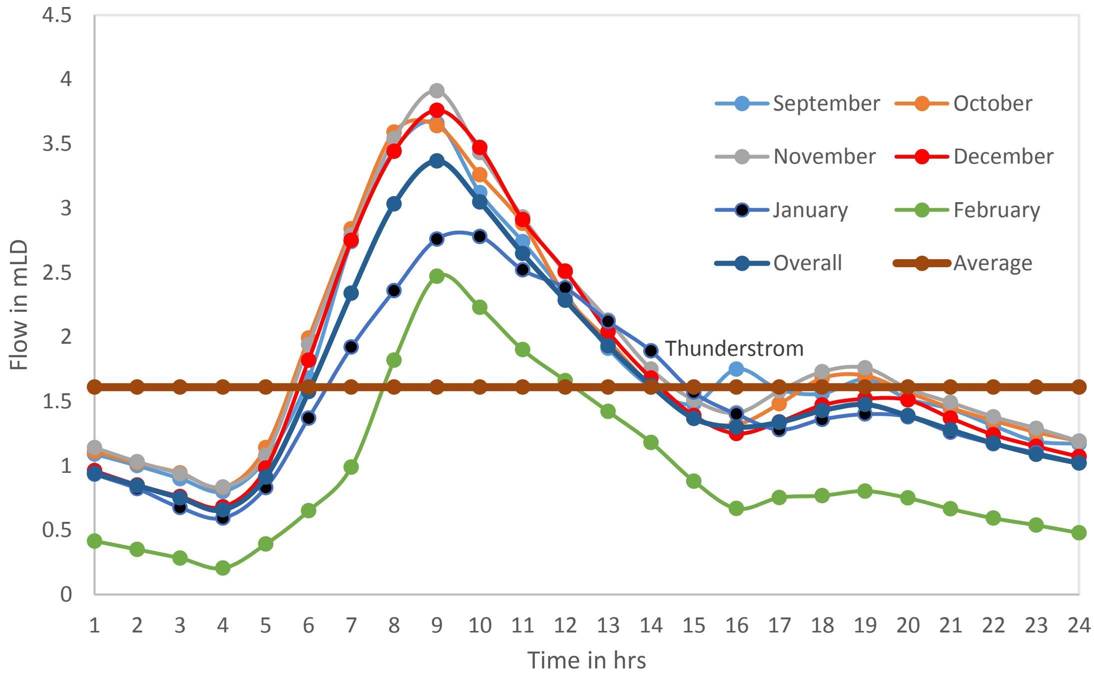


Fig. 3 Hourly inflow variation

4.2 Hydraulic characteristics of Screen and Grit

Hydraulic characteristics parameter shows the performance of installed screen and grit chamber. Range of velocity of flow at approach, velocity of flow through and head loss are shown in table 2 for the screens. Velocity of flow at approach and velocity of flow throgh were found higher than designed value in most of the observation. The higher flow velocity value may cause the occurrence of scouring of coarse material which has stuck in the screen. The performance of grit chamber was assessed by its velocity of flow and surface loading rate. Surface loading rate is an indirect measure of settling velocity. The grit chamber of Sanjauli Maliana STP was designed to sediment the grit particle having high specific gravity (2.65) and measures size of 15 mm or greater with 100% efficiency. Velocity of flow at approach and through was observed experimentally and compared with the theoretical velocity calculated trough design formulae. The comparison has been analysed by applying t-test for independent sample and result inference are reported in the table 3.

Table 2 Hydraullic characteristic of installed screen channel

Parameters	**Sanjauli Maliana STP**			**Design Value**
	Min	**Max**	**Mean**	
Velocity of flow at Approach (m/s)	0.29	1.33	0.750	0.3-0.6
Velocity of flow Through (m/s)	0.63	1.90	1.509	0.8-1.0
Head Loss (m)	0.02	0.24	0.132	0.15-Manual cleaning
				0.15-0.6-Mecahnical Cleaning

Table 3 Hydraullic characteristic of grit channel

Parameters		**Sanjauli Maliana STP**	**Design Value**	**t-test inference**
Velocity of Flow (m/s)	Observed	0.236	0.25-0.4	Theoretical velocity are found significantly higher with the observed velocity in both STP
	Theoretical	0.254		
HRT (s)		60.67	45-90	Insignificant difference has found with Test value 60 seconds
Surface Loading Rate (SLR) (m^3/m^2/day)		293	970	Found significantly lower value in actual with respect to designed value.

4.3 Influent and effluent characteristic

The fig. 4 shows monthly variation of COD, BOD and TSS respectively for the influent as well as effluent against the temperature of sewage and atmosphere (ambient temperature). Influent COD significantly increased with temperature decrement. COD of effluent exceeded the standard discharge limit of 250 mg/L almost every day in winter season. BOD of effluent shows alike trend as COD in fig. 5. The influent BOD was extremely high throughout the winter season as well as effluent BOD exceeded the standard discharge limit of 30 mg/L. The fig. 6 shows trend of TSS variation of inflow and outflow of STP. Influent TSS increased slightly during winter season and effluent TSS exceeded the standard discharge limit of 100 mg/L during the winter season.

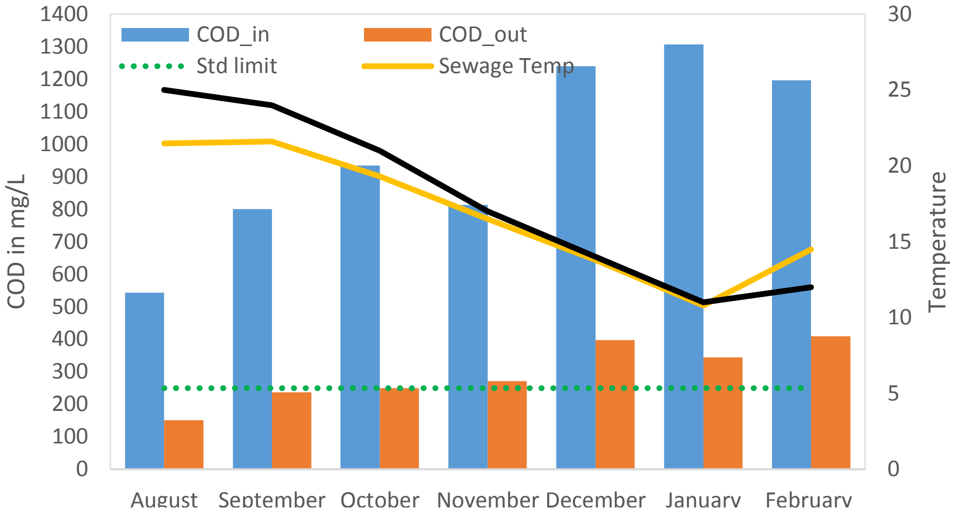


Fig. 4 COD of inflow and outflow w.r.t. temperature of sewage and ambient temperature

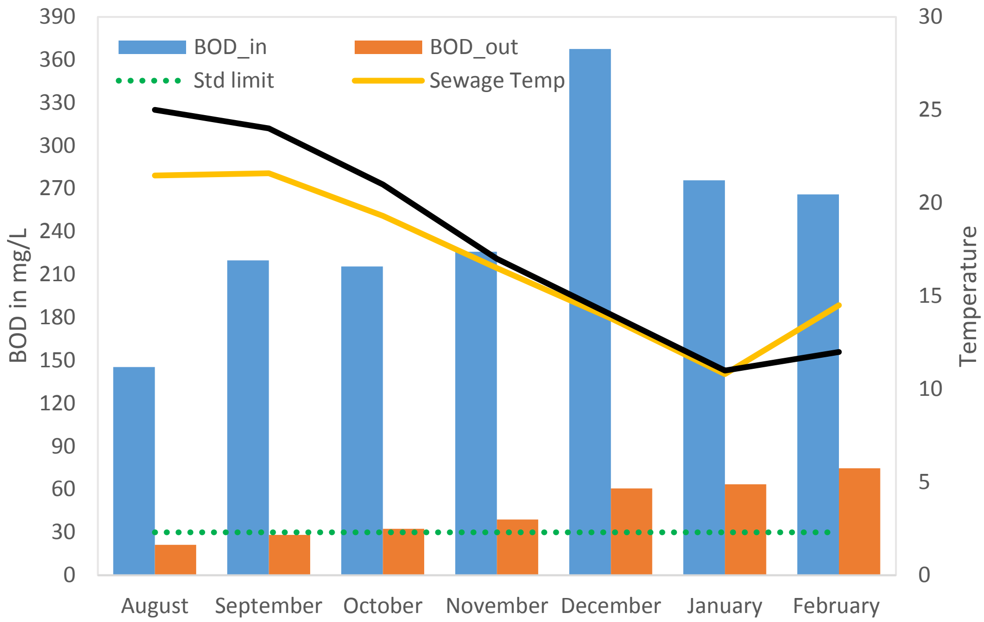


Fig. 5 BOD of inflow and outflow w.r.t. temperature of sewage and ambient temperature

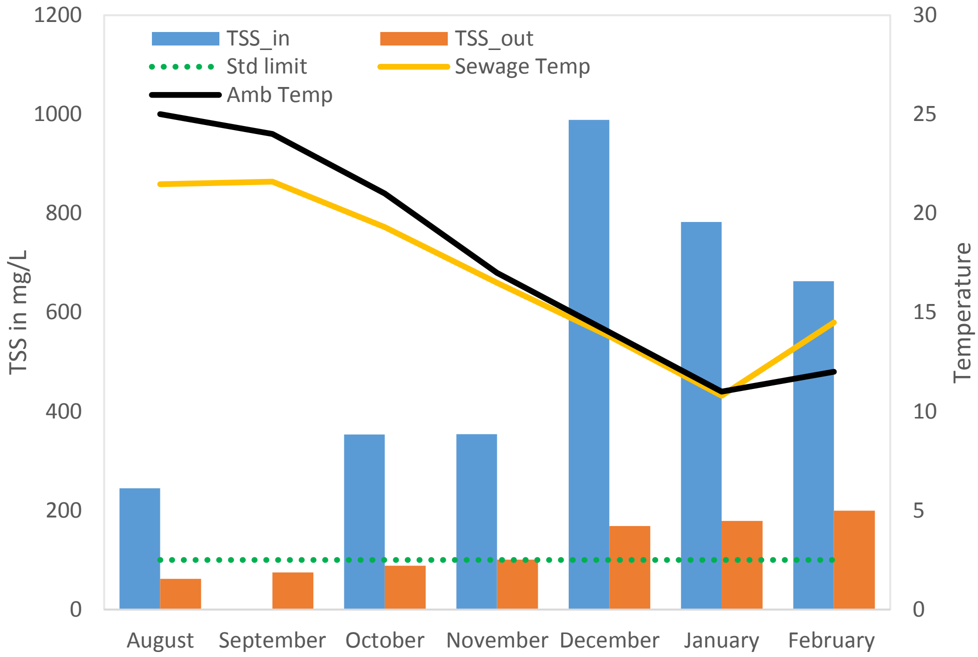


Fig. 6 TSS of inflow and outflow w.r.t. temperature of sewage and ambient temperature

4.4 Efficiency of plant

Efficiency of STP has been indicated in fig. 7 and 8. The graph evidently shows that the removal efficiency of COD, BOD and TSS decreased with temperature decreasing trend. The treatment inside the STP comprised of three stages preliminary treatment, secondary or biological treatment through extended aeration and physiochemical treatment using coagulation and flocculation. The biological treatment efficiency and efficacy is temperature depended thus efficiency of secondary treatment droped during winter season. Similar temperature effect have been found by Singh & Viraraghavan (2003), Kettunen & Rintala (1997), Lew *et al.* (2003), Uemura & Harada (2000) and Coutts & Christianson (1974) on biochemical process of sewage treatment.

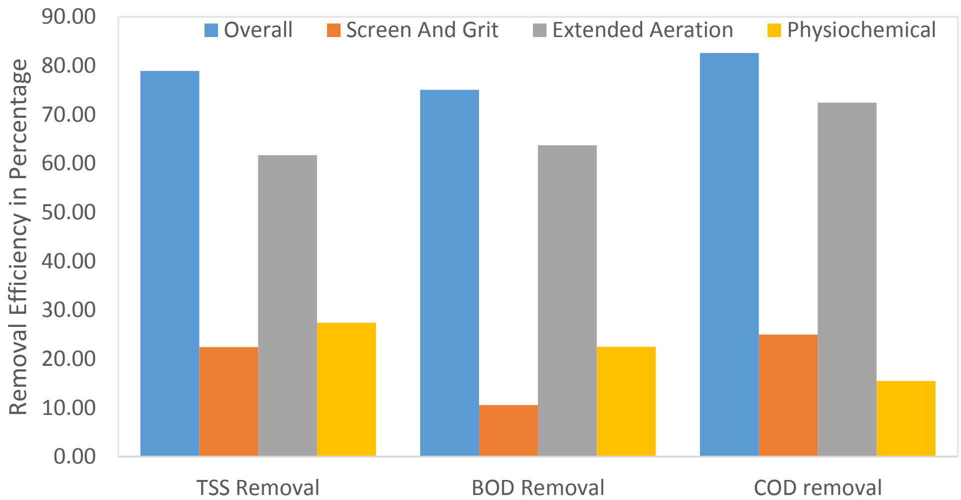


Fig. 7 Removal efficiency of Physiochemical parameters TSS, BOD and COD in each treatment process and overall.

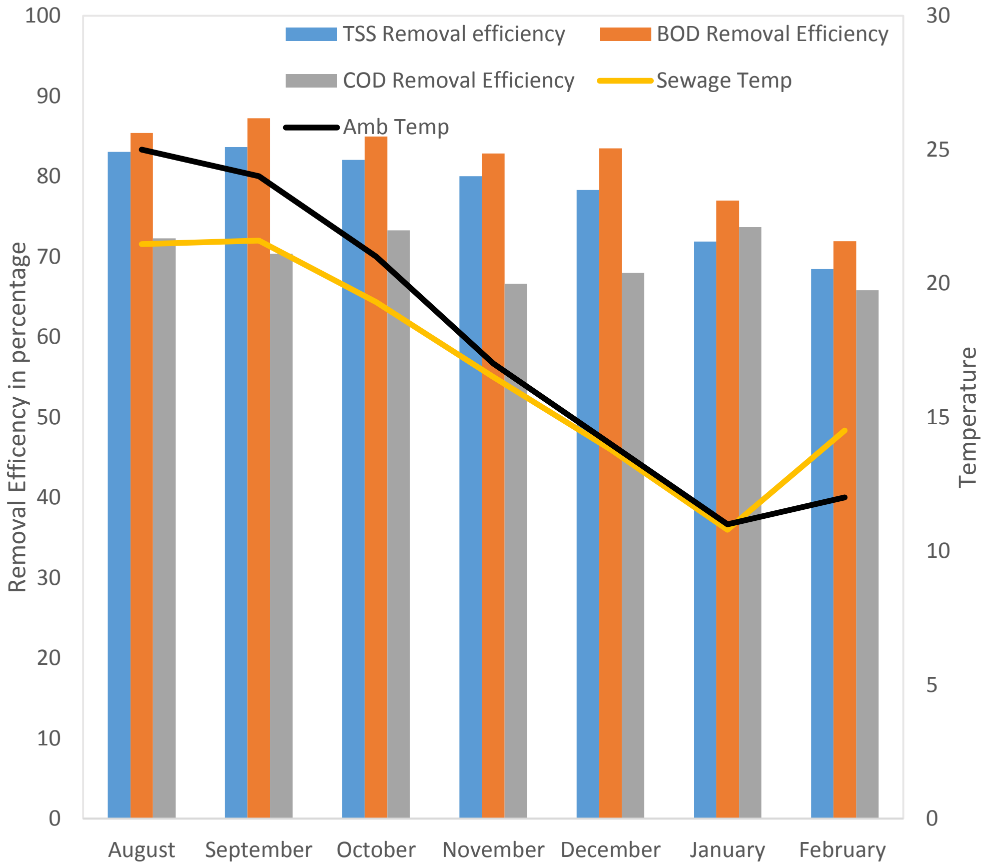


Fig. 8 Month wise removal efficiency of TSS, BOD and COD w.r.t. temperature of sewage and ambient temperature

4.5 Operational parameters of extended aeration

Operational parameters that has important significance but were not tested by plant personnel on daily basis has been studied through laboratory experiments by the author and results are represented in table 4. Operational parameters are not in compliance of the designed value due to operational slackness. Sludge wasting of settled sludge and Sludge Volume Index (SVI) are excessively deviated from optimal design value due to inaccessibility of sludge disposal facility at the existing plant. Installed filter press is not produced dry cakes successfully thus was found idle. The sludge drying beds are very less to manage the excess sludge from reactor thus amount of sludge wasting is very low and recycled sludge has large amount of inactive biomass. SVI value has also be found very low because settled sludge inside the secondary clarifier become more dense due to overburden pressure of accumulated sludge resulted from less sludge wasting. The storage of excess sludge inside the secondary clarifier sternly disturbs the performance of biochemical reactor. Operational parameter of secondary clarifier observed in study has been shown in table 5. HRT value calculated during design itself is very high. Meagre flow through secondary clarifier results all operational parameters significantly below the acceptable range during operation. The settling property is very poor since there is no clear effluent found during experiment, however a quite good amount of sludge observed settled in bottom.

Table 4 Operational parameters of biochemical reactor of extended aeration ASP

Parameters	Observed Value	Design value
Flow in MLD	1.6 (avg) 3.66 (peak)	4.44 (capacity)
BOD (mg/L)	255	350
COD (mg/L)	1381	750
BOD/COD ratio	0.18	.4-.6
MLSS (mg/L)	4330	4000
MLVSS/MLSS ratio	0.82	.75
HRT in hrs	38.49	24
SRT in days	27	30
volume (m3)	2566 (2 tank)	5132 (3+1 tank)
F/M ratio	0.03	0.1
Xr (mg/L)	12140	10000
Xe (mg/L)	249	75-130
Qw (m3/day)	1.07	15-60
Volumetric Loading rate (kg BOD/m3/day)	0.16	0.2-0.4
Qr/Q (required) ration	0.55	0.66
SVI	73.85	80-120
O_2 required as (kg/day) (with altitude correction)	851(4 aerators)	1838(8 aerators)

Table 5 Operational parameters of secondary clarifier at STP

Parameter	Observed Value	Design value
Volume (m^3)	1345	1345 (2 tank)
Overflow Rate (m^3/m^2/day)	2.4	8-15
HRT (h)	14.83	1.5-2.5 7.22 (as per DPR*)
Solid Loading Rate (Kg BOD/m^2/day)	6	25-120
Weir Loading Rate (m^3/m/day)	20	185

*Detailed project report

4.6 Total Coliform

Effluent at outlet of Sanajuli Maliana sewage treatment plant had been tested for presence of indicator microorganism total coliform using MPN method with using five tubes fermentation technique. The biologically cultured sample in controlled laboratory condtions is observed under bright field microscope after applying gram staining technique for the identification of E.coli. The results obtained from MPN has shown in table 6.

Table 6 Total coliform before and after disinfection

Particulars	Effluent without disinfection			Disinfection provided to Effluent using Bleaching powder (5 mg/l)			Standard Limit
Dilution	0.1	0.01	0.001	0.1	0.01	0.001	-
Result	5	4	4	2	2	1	
MPN Table (as total coliform/100ml)		35000			1200		1000
Thomas formula (as total coliform/100ml)		35524			1161		1000

4.7 Power consumption

Power consumption is an imperative data for performance evaluation and energy auditing of STP. The fig. 9 shows the power consumption data averaged over hourly variation plotted with respect to inflow through plant over semi logarithmic graph. The variation in power consumption indicates constant trends with respect to flow. The result demonstrates that there is a overall power usage of 400-500 kWh / MLD of sewage treated by the STP.

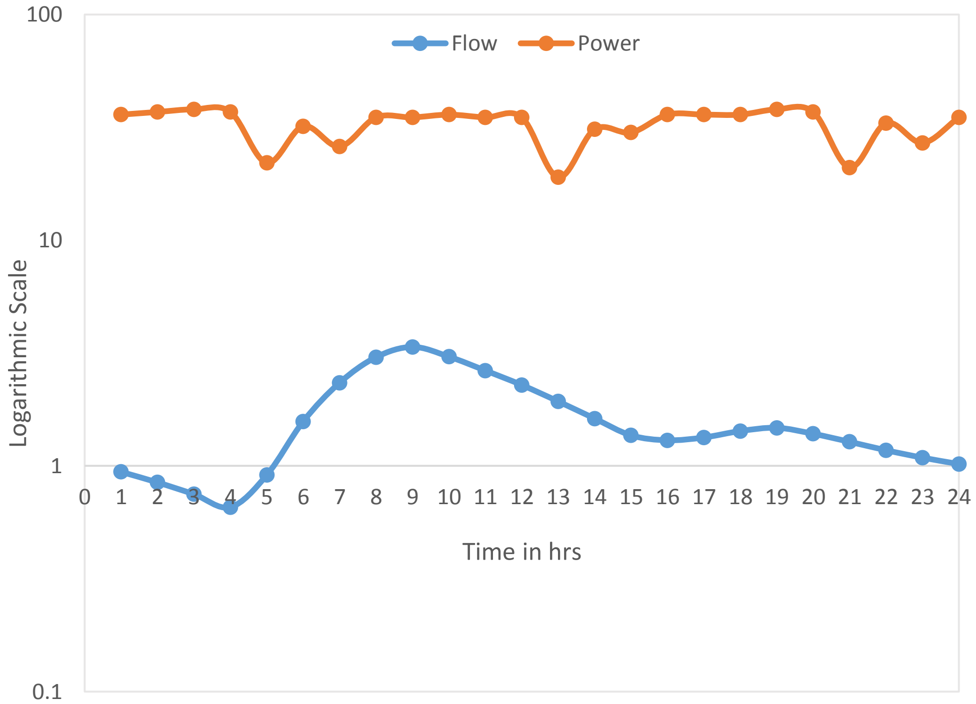


Fig. 9 Semi log plot of hourly power consumption w.r.t hourly flow variation.

4.8 Operational Challenges

Identification of operation challenges during the working of STP in situ would be a crunch point in solving these issues. Desirable efficiency and performance of STP can be achieved, if plant management is able to address the key aspect of the operational problem discussed subsequently.

4.8.1 Shock load

The lesser amount of flow during night may cause sedimentation of solids in sewers which may washed out by peak flow observed in next early morning thus the value of COD, BOD and TSS are observed substantially high in samples collected in the morning. Settlement occurs since the sewer network has undulation due to hilly terrain. STP experiences a severed shock load as high flow and high volumetric loading rate observed every morning especially winter days. The shock load was evident from the test result of samples collected during peak flow in morning as shown in table 7. Capodaglio (2004) has studied effect of wet weather flow on performance of STP and found that a small rainfall for duration greater than time of concentration for the STP can cause high pollutant in sewage during first flush. The high pollutant due to first flush had observed for 2-6 times of average flow which is similar in present study. The plant are experiencing the high pollutant load every day. It has been observed that the amount of grit was quite high during first flush which in turn caused lower BOD/COD as found in present study.

Table 7 Inflow characteristics during peak flow in the morning

Day	Time	COD (mg/L)	BOD (mg/L)	TSS (mg/L)	Conductivity (µS/m)
Day 1	8AM	2000	440	722	1545
	9 AM	2600			
	11 AM	720			
Day 2	8AM	1733	400	1450	1730
	9 AM	2533			
	11 AM	1280			
Day 3	8AM	2667	370	1150	1506
	9 AM	2267			
	11 AM	1067			
Day 4	8AM	2133	520	900	1536
	9 AM	2000			
	11 AM	1360			
Designed Capacity			**375**	**750**	

4.8.2 Chaotic flow with high velocity

The high chaotic velocity indicates the high probability of scouring of coarse material which were trapped in the screen. High velocity of flow occurs due to the difference of ground elevation between source of sewage generation and plant which is 200 to 700 meter. Von Sperling *et al.* (2001) had observed the decrease in effluent quality due to variation in flow which has been evident in the present study. The flow variation can be abridged by installing equalization tank at inlet. In grit chamber the theoretical velocity of flow was significantly higher than the experimentally observed velocity of flow but both values were within the range of designed value which means the unit is working fine. Vasudevan *et al.* (2014) has observed similar results in aeration tank by studying hydraulic characteristic using rhodamine tracer dye and found that the dead storage volume affects the performance of the unit. Dead storage can be reduce by frequent grit removal. The t-test has shown the requirement of equalization tank at the STP inlet to achieve the design speed of screen and grit channel.

4.8.3 Effect of temperature

Removal efficiency of parameters TSS, BOD and COD dropped around 10 to 15 percent during extreme winter condition. Very High strength sewage influent and less biochemical activity during winter season restricts the performance of sewage treatment plant. STP was not capable to treat the sewage water during winter season up to the desired standards. The effluent of STP has not found safe for disposal in the inland surface water bodies this may cause stress over inland surface water bodies which itself have low flow in winter season. The disposal may cause the disease outbreak caused by bacteria, viruses and other microorganisms that spread through fecal-oral route (Rajemahadik and Mendapara 2020). Augmentation of performance of sewage treatment operation was very much required during winter season. The elevated performance can be attained by either increasing efficiency or efficacy of existing treatment system or introducing new polishing unit. During winter season, there was very lesser flow in discharge water body which itself is not adequate to dilute the high pollutant level of discharged effluent. The high pollutants in effluent and lesser flow in discharge body causes severe threat to ecology as well as public hygiene and sanitation in downstream zone of stream.

4.8.4 Impact of sludge wasting and disposal of the wasted sludge

Sludge wasted from the extended aeration treatment process is considered to be organically stable because designed SRT is very high. Recent research has found that the sludge wasted from extended aeration process is not stable even the treatment is conducted under controlled laboratory conditions. The sludge wasted from extended aeration ASP has allowed to decompose in an aerobic reactor inside a laboratory with continuous air supply. The result were monitored in terms of percentage of VSS (biomass) and moisture content over 60 days (time required to achieve constant VSS) of continuous aeration is presented in fig. 10. This study has shown similar results discussed by Ozdemir *et al.* (2014). The wasted sludge is not fit for disposal and may cause disease outbreak if it get mixed through surface runoff.

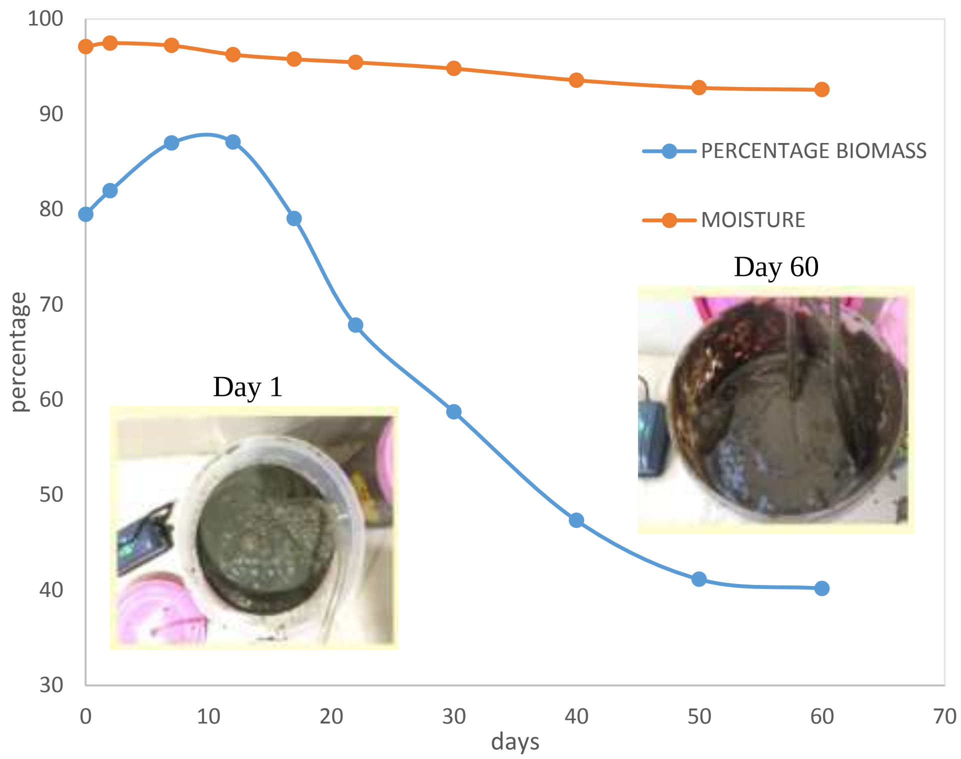


Fig. 10 Percentage reduction in biomass and moisture w.r.t time during stabilization through aeration.

4.8.5 Unskilled operation:

Sampling and laboratory testing had found improper since personnel employed at plant are either unskilled or semi-skilled. The sampling techniques were improper thus representative sample were not collected. Data validation using t-test revealed that the MLSS, TSS and COD test results were significantly different from the test result obtained by author. The reason of error in result was due to higher least count pipette was selected for COD test, non-standard test method of MLSS test and clogging of glass fibre filter used in TSS test. Chatterjee *et al.* (2016) and Kamble *et al.* (2019) has observed that unskilled operations were more vulnerable than the faulty design with respect to performance of the treatment plant. In case of hilly terrain and climate, the plant operators and their skills become more perilous factor. Plant management was not good enough to achieve an attainable efficiency. Active biomass and optimal oxygen level are two most vital monitoring parameter of any type of ASP process. The average monthly variation of MLSS content has shown in the fig. 10.it has been observed that throughout the operation MLSS is not maintained according to design value which causes fluctuation in Food/Microorganism ratio thus overall performance of extended aeration ASP get distressed. In order to boost the performance of biochemical process at Sanjauli Maliana STP, regular monitoring of MLSS and sludge recycling must be done vigilantly. Dissolved Oxygen of aeration tank at Sanjauli Maliana STP has found zero most of the time. The reason may be the low voltage power and poor management in maintenance of aerators. Diffused aerators have also been installed along with surface aerators but they don't operate simultaneously because electric transformer capacity was not sufficient.

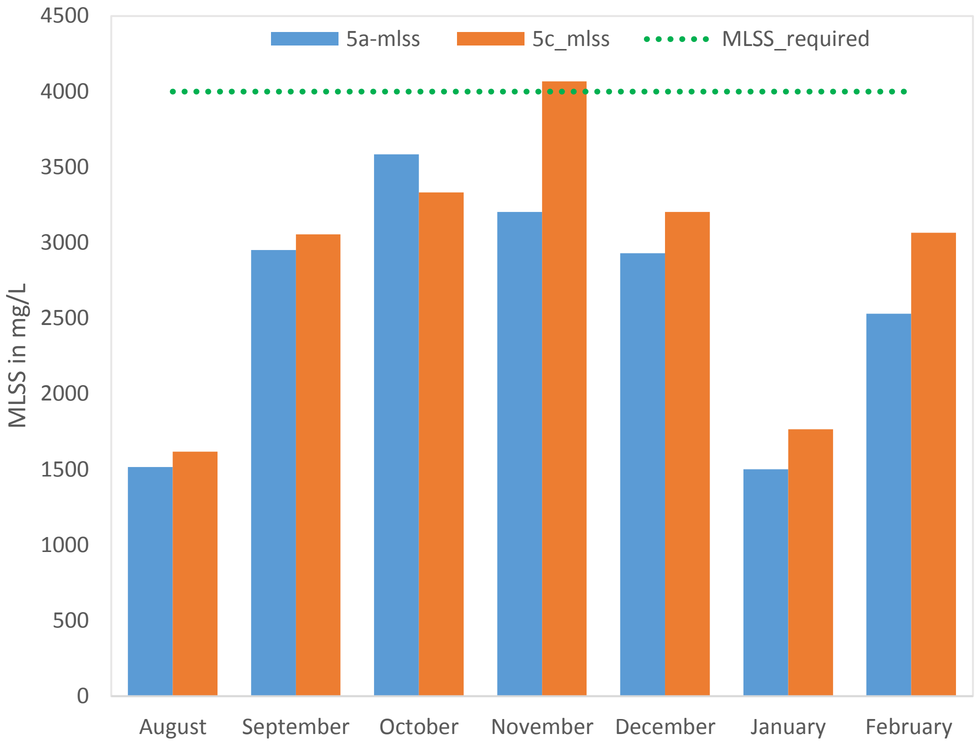


Fig. 11 Month wise average MLSS found in 5a and 5b aeration tank.

4.8.6 Inefficient policing unit

The study shows lesser efficiency of physiochemical process reported by plant personnel with respect to the experimented value which indicates that coagulation flocculation process is underperforming due to operational negligence. There is an urgent need of optimization of physiochemical process that is coagulation flocculation in order to realise an acceptable efficiency of removal through policing unit. There is also a need of proper disinfection in plant since the total coliform value exceeding the standard limit.

4.8.7 Inappropriate power consumption

The trend of power consumption do not follow the variation of inflow. Panepinto *et al.* (2016) has developed an equation for power consumption and found that power consumption depends on flow of wastewater treatment plant. Power consumption should be optimised because it will enhance removal efficiency and reduce the power cost.

5.0 CONCLUSION AND RECOMMENDATION

An equalization tank may be installed at the inlet to moderate the effect of shock load and high velocity. Cold weather in the winter lowers the biological activity thus efficiency of biological process get reduced in the STP. City discharges high strength sewage in the winter season due to high tourist floating population. High strength sewage and lowered biological activity results major offset between effluent quality and its standard limit. Skilled operation, intensive laboratory testing and plant management are key aspect to deal with these issues. Low sludge wasting may cause less active biomass in return sludge. The sludge from extended aeration has not found stable thus it require proper digestion before disposal. Construction of sufficient number of sludge drying bed is recommended to competent authority during this study which was started promptly. Physicochemical process of coagulation and flocculation using alum may be sufficient to polish the effluent from biological process but it requires regular assessment for optimal dosage and skilled operator. Proper disinfection through optimal dose of bleaching powder may restrict the HEV and other viruses to cause disease outbreak. During the study it was observed that similar field study would bring radical turn to overcome the operational challenges of STP especially in developing countries like India.

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