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Research Article

Performance Evaluation Study of Liquid Waste Treatment Plant, Hamidia Hospital, Bhopal, Madhya Pradesh, India

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ABSTRACT:

Treatment and proper disposal of Biomedical waste both solid and liquid from various health centres being hazardous and infectious in nature is of foremost concern. Among these, liquid infectious wastewater generated from hospitals is of primary preoccupation as most times, it is being discharged in public drainage or sewer line with inadequate treatment presenting a risk to health of livings and on the environment. So, the efficacious treatment of liquid wastewater from hospitals is obligatory. With this view, a Liquid Waste Treatment Plant (LWTP) was initially established for Hamidia Hospital, Bhopal in 2014. This plant performs physicochemical treatment to the hospital liquid wastewater including disinfection. The objective of the study is to evaluate performance efficiency of the Liquid Waste Treatment Plant (LWTP), Hamidia Hospital, Bhopal, MP, India in terms of removal of pollutants. Composite Sampling was performed at different stages of the treatment units and the major water parameters analyzed were – pH, SS, TDS, BOD, COD, Oil & Grease, microbial parameters including Total *Coliform* (TC) and Faecal *Coliform* (FC). The overall percentage Removal Efficiency (RE) of LWTP for these parameters is found to be admissible for SS, COD, BOD and Oil & Grease as 81.72%, 72.95%, 83.48% and 100% respectively. However for TDS it shows negation with – 50.32%. For microbial parameters the results are excellent. Heavy metals analysis was also performed in the treated water reveals all the values are under the permissible limits. The results represent acceptable performance of the LWTP.

KEYWORDS: Liquid Waste Treatment Plant (LWTP), Bio-medical waste, Performance study, Pollution, Health centres, Waste management

INTRODUCTION

Health is of major concern in any country and proficient medical care is vital for this. Developments in medical facilities in last few decades have opened many new options for better health and life. But, this has also increased the quantum of waste generated from medical units like hospital, public health centres, central care units, medical colleges and

research centres, veterinary hospitals and others. The biomedical wastes generated from health care facilities if not managed properly being hazardous and infectious poses a serious threat to the health of people and on the environment.

Proper discrimination and effective management of biomedical wastes is a real problem that every nation is facing at present. Taking this in concern Indian government has first come up with Biomedical Waste (Management and Handling) Rules, 1998. After that in 2016, Biomedical Waste (Management and Handling) Rules, 2016 were issued which underwent last amendment in 2019 says "Bio-medical waste means any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining there to or in the production or testing of biological, and including categories mentioned in Schedule I of Biomedical Waste (Management and Handling) rules 2016". (Govt. of India 2016)

Even in the availability of Biomedical Waste (Management and Handling) rules 2016, more concern is given to solid BMW management and liquid wastewater from health centres is generally discharged in to public drainage or sewer line, surface water sources and percolates into underlying ground water without any or after some minimal treatment posing serious health hazards to livings (Stringer 2011). Liquid wastewater emerging from hospitals, public health care centres, medical colleges and research centres, blood banks, veterinary etc. is of top concern as it includes hazardous components like infectious waste, laboratory wastes, Photographic chemicals, wastewater from cleaning and washing, more drug-resistant pathogens, a greater variety of chemicals, solvents, disinfectants, pharmaceuticals and radionuclide along with domestic waste water. A study by WHO mentions that hospital wastewater consists of domestic waste (85%), infectious waste (9.5), sewage pathogens (1.5%) and hazardous waste (4%). (WHO 2013)

Treatment of liquid waste generated from health centres prior to their disposal as per Biomedical Waste (Management and Handling) Rules, 2016 is also an important part of BMW management. In this perspective, a Liquid Waste Treatment Plant (LWTP) was established by Public Health Engineering Department, Bhopal, MP, India on 12th Aug, 2014 initially for treatment liquid waste generated from Gandhi Medical College and Hamidia Hospital, Bhopal, Madhya Pradesh, India. Hamidia Hospital, earlier known as Prince of Wales King Edwards Memorial Hospital is a multispecialty tertiary care teaching hospital affiliated to Gandhi Medical College which are among the large hospitals of Bhopal city having 900 beds facilities generating large volumes of liquid waste. Later this facility has also been opened for the treatment of sewage from residential area in the premises and hostels of medical college.

The design capacity of Liquid Waste Treatment Plant (LWTP) is 0.5 MLD. Treatment plant was established such that no pumping is required for treatment of liquid waste as from first to last unit of treatment plant the flow can be assured as gravitational flow. Liquid waste is treated in accordance to Biomedical Waste (Management and Handling) Rules, 2016, where coagulation is done with alum and liquid chlorine is used for disinfection. The final treated liquid waste from LWTP is then transfer into Fatehgarh sewage pump house under Public Health Engineering Department where the treated liquid waste is mixed with sewage of Bhopal city and then pumped through Barkhedi sewage pump house to Maholi Damkheda Sewage Treatment Plant, where the wastewater is further treated. This Treated waste finally disposed off into Patra nallah.

The Google Earth image of the LWTP with coordinates is given in Fig. 1. The plant consists of Screen Channel, Aerated Grit Unit, Coagulation Tank, Flocculator, Clarifier, Sludge drying Beds and Disinfection by liquid Chlorine at outlet of clarifier. The details of all treatment units are mentioned in the Table 1.

Fig. 1: Google Earth Image of Liquid Waste Treatment Plant, Hamidia Hospital, Bhopal, MP, India (Co ordinates- $23^0$15'26.21"N, $77^0$23'34.30"S)

Table 1: Technical Details of Liquid Waste Treatment Plant (LWTP), Hamidia Hospital, Bhopal, MP, India

S. No.	LWTP Unit	Qty.	Dimensions	Capacity
1	Screen channel	1	0.75m x1mx 0.10m	0.075 m^3
2	Aerated Grit Unit	2	1.5m x 1m x 0.75m	1.125 x 2= 2.25 m^3
3	Coagulation Tank	1	0.75m x 0.75m x 1m	6.28 m^3
4	Flocculator	1	2.6m x 2.2m x 2m	11.44 m^3
5	Clarifier	1	5.5m dia. x 2.5m depth	13.75 m^3
6	Sludge Drying Bed	2	25 m^2	50 m^2

A Brief of Liquid Waste Treatment Plant (LWTP), Hamidia Hospital, Bhopal, MP, India:

Liquid waste from Gandhi Medical College, its residential and hostel sewage, and Hamidia Hospital comes in Inlet from respective sources. Inlet is fitted with V-notch for assessment of flow rate. Liquid waste then enters into Aeration Grit unit through screen channel which separates out solid wastes if present any. Aeration Grit units are fitted with air blowers for proper homogenization and decomposition of easily decomposable soluble organic matters. Alum as coagulant is added into the Coagulation Tank after aeration which is followed by flocculation. In Flocculator, flocs are allowed to form so that maximum settlement can be assured in Clarifier. Liquid waste is then passed to Clarifier with laminar flow so the flocs formed can be settled and treated effluent can be taken out. The Clarifier outlet is disinfected by adding calculated amount of liquid chlorine continuously to the effluent. The sludge collected from the Clarifier is set to dry in two sludge Drying Beds. The dried sludge is sent to Treatment, Storage and Disposal Facility (TSDF) for hazardous wastes at Pithampur, Indore, MP, India. Flow Diagram of Liquid Waste Treatment Plant (LWTP), Hamidia Hospital, Bhopal, MP, India is shown in the Fig. 2.

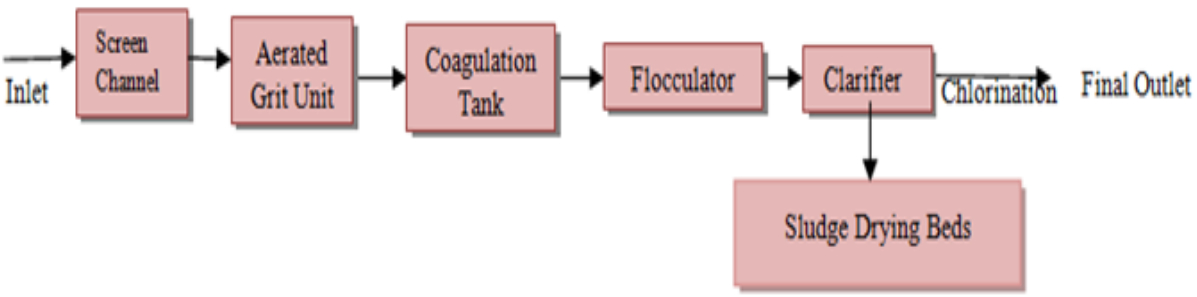

Fig. 2: Flow diagram of Liquid Waste Treatment Plant, Hamidia Hospital, Bhopal, M.P., India

MATERIAL AND METHODOLOGY

Liquid wastewater form hospitals contains harmful pollutants such as medicine residuals, laboratory wastes (phenols, chloroform, antibiotics), pathogenic micro-organisms (bacteria and viruses), biodegradable organic matters (protein, fats and carbohydrates, chemical toxid like (Pb, Hg), domestic waste (from kitchen, laundry, washing and cleaning) etc. can influence aquatic ecosystem and harmful for livings. Some of the components in liquid wastewater are even having cytogenic and mutagenic potential. It is estimated that average per capita production of waste water in a hospital is to be 400 litres/ person/ day; however, this amount of liquid waste generated may differ from hospital to hospital (Codina & Vecente 1994). The study was planned to assess the performance of Liquid Waste Treatment Plant, Hamidia Hospital, Bhopal, MP, India for which composite sampling was done on in 5 July, 2019 at regular time intervals at different treatment points including Inlet, Clarifier Outlet and Final outlet. The average load of wastewater produced per day is 9.3 m^3. The performance evaluation of the Liquid Waste Treatment Plant (LWTP) was carried out based on the calculation of Removal Efficiency for the selected wastewater parameters proposed in Biomedical Waste (Management and Handling) rules, 2016 (Govt. of India 2016) as Suspended Solids (SS, in mg/L, Gravimetric method), Total Dissolved Solids (TDS, in mg/L, Gravimetric method), Biochemical Oxygen Demand (BOD, in mg/L at 27°C for 3 days by Bioassay Procedure using Winkler's method), Chemical Oxygen Demand (COD, in mg/L, Open Reflux method), Oil and Grease (O & G, in mg/L, Solvent Extraction method) and Total *Coliform* and Faecal *Coliform* (Most Probable Number method) and some heavy metal toxid- Pb, Hg, Fe etc by Atomic Absorption Spectrophotometric method (APHA, AWWA and WEF 1995 & Central Laboratory Test Methods 2001). The pH is measured for all the points with pH meter by Potentiometric method (APHA, AWWA and WEF 1995 & Central Laboratory Test Methods 2001). Overall Removal Efficiency (RE) was calculated for the mentioned parameters at Inlet point, Clarifier Outlet point and Final Outlet point. To confirm the toxicity level of the treated waste water, Heavy Metal analysis was also performed at the Outlet. The data was compared with the quality standard of wastewater that has been set under Bio Medical Waste (Management and Handling) Rules 2016, Schedule II (8) to determine the effectiveness of Liquid Waste Treatment Plant (LWTP).

The samples were collected and preserved on the spot as per the standard procedure and requirement of dictated parameter and transported to the laboratory and stored at +4°C until they were analysed. Personal Protective Equipments (PPEs) were taken in properly with care while sampling. All the analyses were performed in the Laboratory, Central Pollution Control Board (Central), Regional Directorate, Bhopal, MP, India consistent with standard methods of wastewater analysis mentioned in APHA, AWWA and WEF 1995, 'Standard methods for the examination of wastewater', 19th edition, American Public Health Association, American Water Works Association, and Water Environmental Federation, Washington. D.C. and Central Laboratory Test Methods, Volume-1 and Volume-2, Central Pollution Control Board, Parivesh Bhawan, East Arjun Nagar, Delhi, DOC: CB/CL/TM/9, Issue No.: 01, Issue date: 15/01/2001.

RESULTS & DISCUSSION

To investigate the performance of different units in the overall treatment efficiency of the plant and to evaluate the performance of aeration tank based on some of the standard operational parameters comprising of Suspended Solids (SS), Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD), Oil & Grease, Total *Coliform* and Faecal *Coliform*, Removal Efficiency (RE) was calculated at three different point including Inlet, Clarifier Outlet and at Final Outlet after disinfection;

while Dissolved oxygen (DO) is determined for the Aeration Grit Unit was found to be 1.68 mg/L. The calculated values of above mentioned parameters along with their Removal Efficiency are referred in Table 2 while the pH calculated at different points is given in Table 3. Prescribed Limits of Standard Parameters for the discharge of Liquid Wastewater as per BMW Rules, 2016 and the calculated values for the same at Final Outlet of LWTP, Hamidia Hospital, Bhopal, MP, India are mentioned in Table 4.

pH is an important parameter to assess proper working of coagulants added and the quality of the final treated water discharged. During the study, the values of pH for the effluent were found to be 7.88, 7.42 and 7.39 at investigated points- Inlet, Clarifier outlet and Final outlet which is reasonable for the performance.

The results obtained for the analysed parameters reveal that all the examined parameters show declination towards the final outlet except for the TDS, showing satisfactory performance of the plant. The overall efficiency was also calculated for these parameters and results at Final Outlet when compared with the standard permissible limits given for the studied parameters in Biomedical Waste (Management and Handling) Rules 2016, Schedule-II (8) unveils that all the parameters are under limits described for the same and the plant is showing adequate performance towards the treatment of hospital liquid wastewater.

The characteristics and overall Removal Efficiency measured for all parameters depend on the inlet effluents load and efficiency of the treatment units. Low BOD to COD ratio depicts that the liquid waste does content more inorganic impurities rather than organic impurities and thus physico-chemical treatment is sufficient for proper treatment of the liquid waste (Pauwels & Verstraete 2006). The overall Removal Efficiency for COD is 72.95 % and that of BOD is calculated as 83.48 %. For the parameter Oil & Grease 100% percent Removal Efficiency was achieved at the Final Outlet. The gradual increase in the value of TDS from Inlet to Final Outlet can be interpreted as of addition of different chemicals like Alum, Hypochlorite for coagulation of colloidal impurities present in the waste water, while gradual decrease was observed in the value of suspended Solids from Inlet to Final outlet with overall Removal Efficiency of 81.72.

As wastewater from medical facilities is contaminated with many microbes, the analysis of it for microbial parameters like Total *Coliform* (TC) and Faecal *Coliform* is an important part of the study. The result reported nil for both Total *Coliform* (TC) and Faecal *Coliform* (FC) at the Final outlet. Heavy Metal analysis report of the treated wastewater communicates that the concentration of all the heavy metals studied like Cadmium (Cd), copper (Cu), Lead (Pb), Nickel (Ni), Zinc (Zn) and Iron (Fe) were found under the standard limits at Final outlet. For the heavy metals Cadmium (Cd), Copper (Cu), Chromium (Cr), Lead (Pb), Nickel (Ni) were determined below the detection limits (BDL), while Zinc (Zn) and Iron (Fe) were found 0.079 mg/ L and 0.025 mg/L respectively. The plot of characteristics of the assessed parameters with the Overall Removal Efficiency at inspected treatment points is shown in Fig. 3.

CONCLUSION

The wastewater generated from hospitals, other health care units and medical facilities has high loads of pollution with many pathogenic microbes, if discharged untreated having strong potential to pollute both surface and ground water. And if discharged with municipal wastewater its complete and effective treatment is not possible which can have hazardous consequences on public health. So, on-site treatment of hospital wastewaters before discharging is required and it is necessary that hospitals should opt for installation of separate efficient Liquid Waste Treatment Plants or some common facilities for the treatment of generated wastewater. This study affirms that the performance of Liquid Waste Treatment Plant (LWTP) installed by Hamidia Hospital, Bhopal, MP, India is satisfactory in the

treatment of generated wastewater as all the important parameters like pH, SS, TDS, BOD, COD, O/G, TC, FC and heavy metals are under the permissible limits. The overall percentage Removal Efficiency (RE) of LWTP for the studied parameters was found to be admissible for SS, COD, BOD and Oil & Grease as 81.72%, 72.95%, 83.48% and 100% respectively. The results of microbial study and heavy metals also represent acceptable performance of the LWTP.

Table 2: Removal Efficiency of studied Parameters at inlet , clarifier outlet and final outlet points of Liquid Waste Treatment Plant (LWTP), Hamidia Hospital, Bhopal, Madhya Pradesh, India
(Date of sampling: 5th July, 2019)

Parameters Analysed	Inlet	Clarifier Outlet	Final Outlet	Inlet to Clarifier outlet	Clarifier outlet to final outlet	Overall Removal Efficiency (%)
				Removal Efficiency (%)	Removal Efficiency (%)	
Suspended Solids (SS) mg/L	186	38	34	79.56	10.52	**81.72**
TDS (mg/L)	620	948	932	-52.9	1.68	**-50.32**
COD (mg/L)	318	96	86	69.81	10.41	**72.95**
BOD (mg/L) at 27° C for 3 Days	109	23	18	78.9	21.73	**83.48**
Oil & Grease (mg/L)	2.8	-	BDL	-	-	**100**
Total *Coliform* (by MPN)	TNTC	-	Nil	-	-	**100**
Faecal *Coliform* (by MPN)	TNTC	-	Nil			**100**

TNTC (Too Numerous To Count) *BDL (Below Detection Limit)

Table 3: pH measured at different treatment units of Liquid Waste Treatment Plant (LWTP), Hamidia Hospital, Bhopal, Madhya Pradesh, India

S. No.	Treatment Points	Measured pH
1	At Inlet	7.88
2	Clarifier Outlet	7.42
3	Final Outlet	7.39

Table 4: Comparison of calculated values at Final Outlet with Standard Permissible Values of Parameter as per Biomedical Waste (Management and Handling) Rules, 2016
(Liquid Waste Treatment Plant (LWTP), Hamidia Hospital, Bhopal, Madhya Pradesh, India)

S. No.	Parameter Analysed	Standard Limits of Discharge as per BMW (M & H) Rules, 2016	Calculated value at Final Outlet
1	pH	6.5 to 9.0	7.39
2	Suspended Solids (SS)	100 mg/L	34 mg/L
3	Oil & Grease	10 mg/L	0.00 mg/L
4	BOD	30 mg/L	18 mg/L
5	COD	250 mg/L	86 mg/L

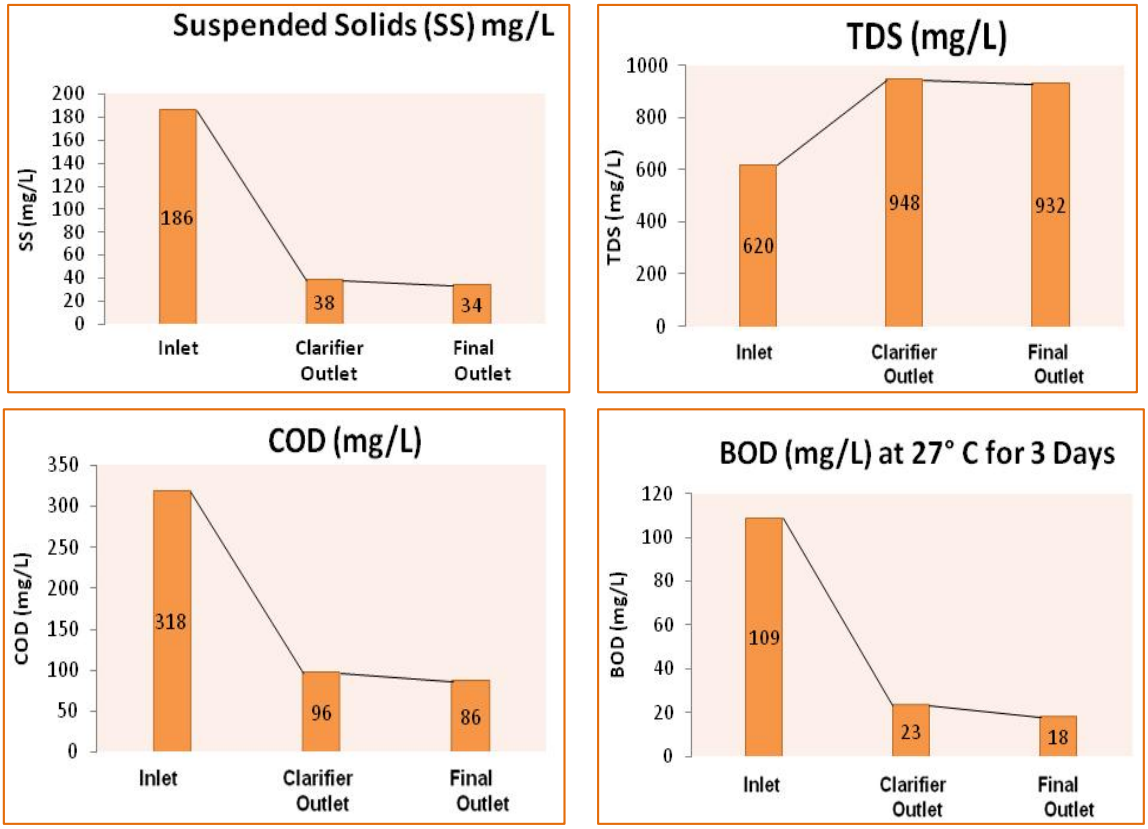

Fig. 3: Plots of assessed parameters SS, TDS, COD and BOD at inspected treatment Points (Liquid Waste Treatment Plant (LWTP), Hamidia Hospital, Bhopal, Madhya Pradesh, India)

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