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Evaluation of STPs in Jamshedpur city: design of a 45mld STP and reuse option in Jamshedpur city

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ABSTRACT

Effluent quality of the treated wastewater is an important parameter for its reuse. Comprehensive data on the raw and treated effluent of domestic, medical, industrial effluent characteristic are not available in Jamshedpur city, therefore a comparative study of the existing treatment plants in the city was carried out to access the effluent quality for present and future reuse. The study further evaluates the water of 6 STPs in Jamshedpur and 1 STP in Puri. For the reuse of the treated wastewater four parameters are necessary to check i.e. BOD, COD, TSS, pH which was carried out in the study. These STPs are based on the Activated Sludge Process (ASP), Anaerobic treatment (UASBR), BIOFORE, MBBR.STPs employing MBBR and UASBR technology showed the better removal of COD, BOD, and TSS removal as compared to other treatment process based on STPs. There could be improvisation in the current wastewater treatment for better treatment so; a proposed treatment scheme is designed for wastewater treatment plant after the study of different treatment plants. Based upon the physical, chemical, and microbiological removal efficiencies, the actually integrated efficiency of each STP was calculated (IEa) to evaluate its suitability for reuse in irrigation, gardening, and industrial purpose. Two biggest plants of Jamshedpur "kharkai" and "bara" required modification in the treatment process for better reuse of the effluent. Possible reuse option in Jamshedpur and Puri depending on the geographical location has been investigated which include gardening, automobile washing, boiler feed, cooling towers, irrigation, etc. All the experiments were done in Bara laboratory and some necessary data were taken from JUSCO Ltd (Jamshedpur).

Keywords— *Sewage treatment, Reuse, Design of STP, UASBR, MBBR, BOD*

1. INTRODUCTION

Jamshedpur city is considered as the first industrial town of India and is located in the Jharkhand state of India. The city has two major rivers as a source of water. It is a much-developed place and there are a number of STPs with good treatment efficiency and employing different treatment process. But it is not that efficient so that the treated sewage can be reused as a whole. To overcome this problem the reuse of the treated sewage should be implemented in many aspects wherever possible and the treatment process should be modified where it is required. So, the study of different sewage treatment plant was done to check which treatment process has better treatment capacity.

In the present time, there are various types of wastewater treatment process some of them which are ASP, MBBR, MBR, UASBR, SBR, Anaerobic Digestion, Electro-coagulation, Trickle-Bed Reactor, Ultra-Filtration and much more. But most widely used are ASP, MBBR, and UASBR.

In a sewage treatment plant, the activated sludge process (ASP) is a biological process that is mainly used to remove the biological matter, nutrients, ammonium and nitrogen in organic matter. The MBBR system consists of an aeration tank with special plastic media where the growth of bacteria is enhanced. The carriers are made of a material with a density close to the density of water and are mixed in the tank by aeration process. The process doesn't need recycling of sludge. The MBBR system is often added to the existing ASP to increase the capacity of the system. In Membrane Bio Reactor (MBR) membrane processes like microfiltration and ultra filtration are joined with a biological treatment process like ASP, and this process is now widely used in industrial and municipal wastewater treatment. The Sequential Batch Reactor (SBR) process treats wastewater after an output from anaerobic digestion which is facilitated in batches and thereafter the aeration is provided through the mixture of wastewater and activated sludge which reduces the organic matter i.e. BOD and COD. Up flow Anaerobic Sludge Blanket Reactor (UASBR) process includes anaerobic digestion and produces methane in the digester, the efficiency is very high in this process of treating domestic wastewater.

Table 1: Showing the design flow, current average flow and STPs employing different treatment process

Sewage treatment plants	Technology	Design flow (KLD)	Present average flow (KLD)
Kharkai	ASP	$16*10^3$	$10*10^3$
Bara	ASP	$45*10^3$	$30*10^3$
Golmuri	MBBR	50	50
TMH	MBBR	100	100
TATA CUMMINS	BIOFORE	150	16
Pejo-Nala “Puri”	MBBR	50	30
BURMAMINES	UASBR	30	30

2. METHODS

LAB TESTS: Lab tests those are necessary to check the water quality of raw and treated sewage are BOD, COD, TSS, pH. All the lab tests were performed in “Bara Laboratory” after the test the sewage characteristic of different raw effluent like medical, industrial and domestic effluent were known.

SAMPLING: The following observations were made after the laboratory experiments. The samples were collected from every treatment plants twice a month during the period of January 2018 - April 2018. The samples were collected one from the inlet and one from the outlet from every treatment plant in a 1-liter bottle and were immediately given to the “Bara-laboratory” for testing of pH, BOD, COD, TSS.

OBSERVATIONS: The following observations were made after the lab test of sewage from various STPs

Table 2: Showing the average inlet and outlet parameters of various STPs

Name of treatment Plant	Average Inlet BOD	Average Inlet COD	Average Inlet TSS	Average Inlet Ph	Average Outlet BOD	Average Outlet COD	Average Outlet TSS	Average Outlet pH
Kharkai STP	108.5	204.75	182	7.2	10.93	35.75	13.81	7.61
Bara STP	106	205.75	193	7.21	13.86	33.11	21.67	7.64
Golmuri PSTP	105.1	240	218.27	7.4	9.68	30.88	13.31	7.48
UASBR-Burmamines	122.25	206.75	143.38	7.01	7.93	14.62	9.88	7.34
TATA CUMMINS ETP	131	1253.38	380.75	7.45	11.56	42	15.38	7.46
TMH ETP	252	413	48.06	7.62	7.88	40.94	8.94	7.53
Pejo-Nala, Puri	21800	24666	95.33	7.92	6	27.5	5.17	7.55

Table 3. Table showing the efficiency of each STPs and Integrated Efficiency.

Name of the treatment plant	% Removal of BOD	% Removal of COD	% Removal of TSS	Average Outlet pH	Integrated Efficiency
Kharkai STP	89.92	82.54	92.41	7.61	88.29
Bara STP	86.92	83.91	88.77	7.64	86.53
TMH ETP	96.87	90.1	81.40	7.34	89.45
Golmuri PSTP	90.79	87.13	93.90	7.48	90.61
TATA CUMMINS ETP	91.17	96.64	95.96	7.46	94.59
Pejo-Nala, Puri	99.97	99.88	94.57	7.55	98.14
UASBR-Burmamines	96.87	90.1	81.40	7.53	89.46

Integrated efficiency = IEa = 1/3(E_{BOD}+E_{COD}+E_{TSS})

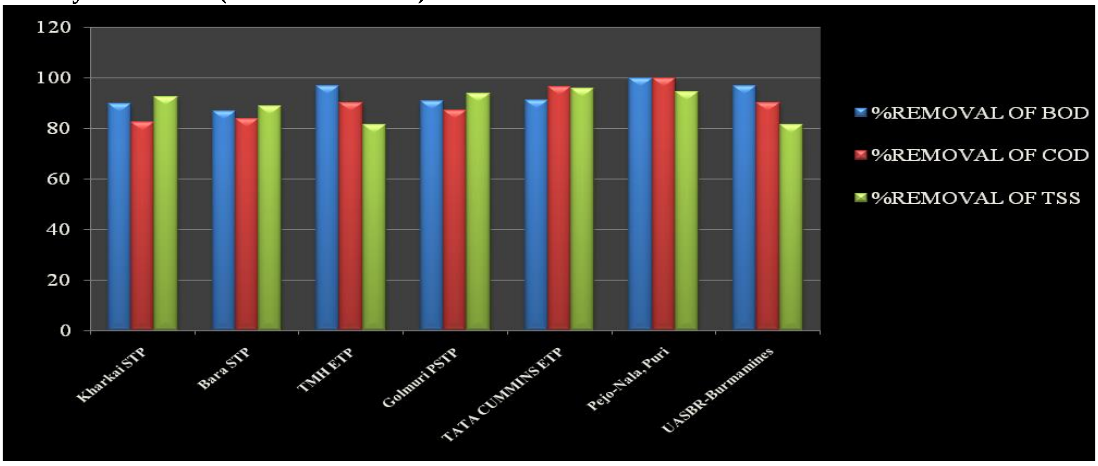

Fig. 1: Showing the average removal efficiency of BOD, COD, TSS

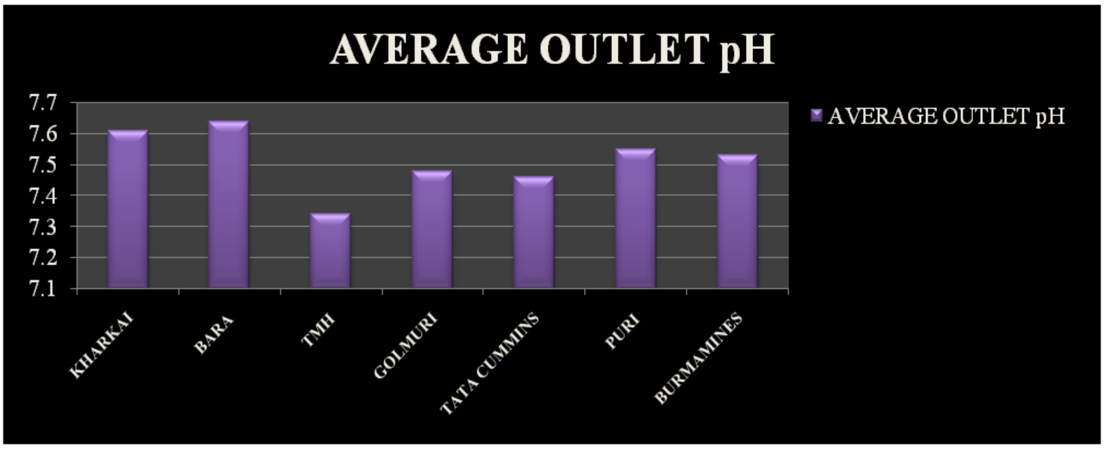

Fig. 2: Showing the average outlet pH of different STPs

3. DELINEATION OF PROPOSED TREATMENT SCHEME

3.1. Design Considerations

1. Present Flow = 45MLD
2. Maximum flow = Considering 5MLD excess flow during high time (maximum).
3. Ultimate flow including 5 MLD future flow =50*1000/3600/24 = 0.579 m^3/s.
4. Peak factor=2.25
5. Peak flow-maximum = 50*1000*2.25/24/3600 = 1.302 m^3/s.
6. Peak flow-present = 45*1000*2.25/24/3600 = 1.172m^3/s.
7. Ave flow-present = 45*1000/24/3600 = 0.521m^3/s
8. Average inlet BOD = 300mg/l
9. Average Inlet COD =400mg/l
10. Inlet Suspended solids = 750mg/l.
11. Average Inlet Sulphate = 85mg/l
12. Final BOD required =< 5mg/l

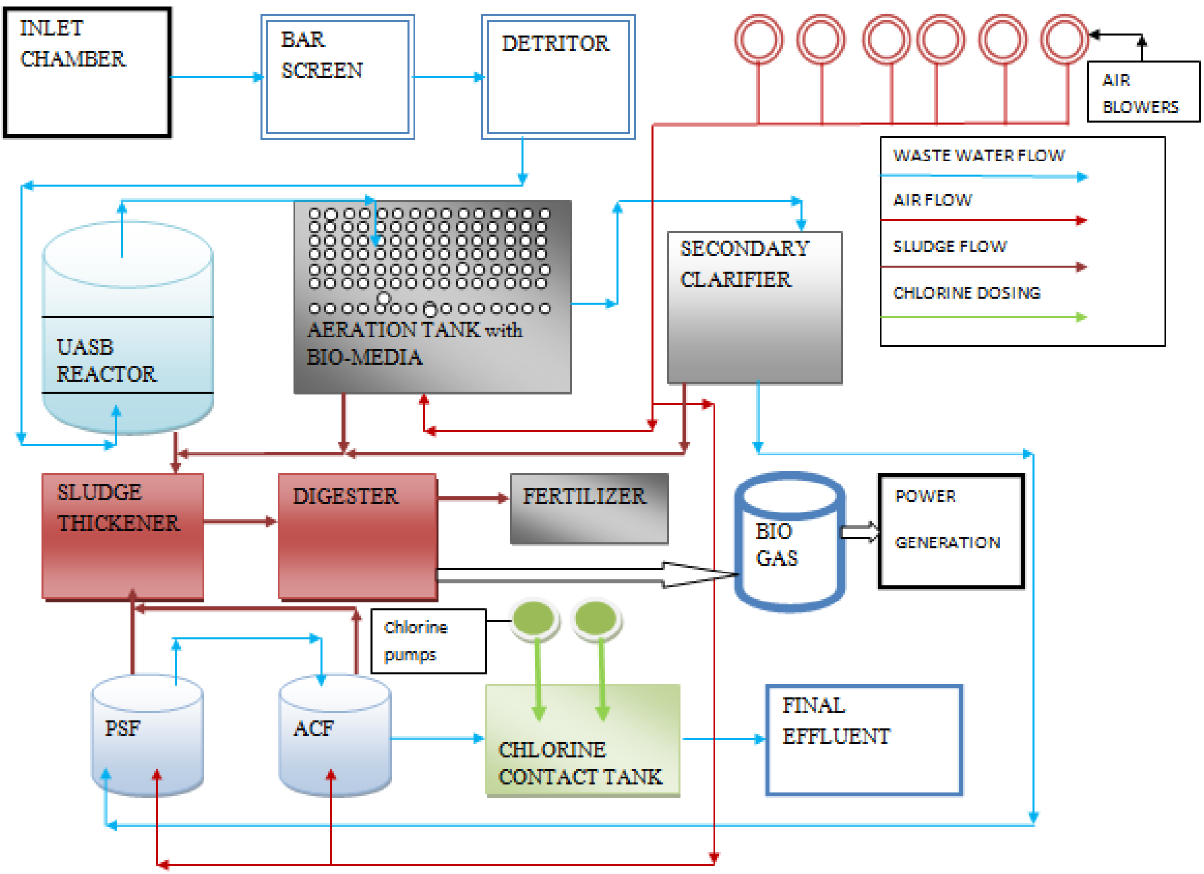

Fig. 3: Showing the flow diagram of the proposed treatment scheme

3.2. Design of Inlet Chamber

1. Total No = 1
2. Design flow = 1.308m^3/s
3. Volume of tank = 60*1.308 = 78.12m^3

4. Provide liquid depth = 3m
5. Therefore, Area = 78.12/3 = 26.04m^2
6. Provide width = 2.4m
So, length =26.04/2.4 = 10.85m
Hence provide length of 11m.
Hence provide 1 No. of 11m*2.4m*3m LD+ 0.3m FB

3.3. Design of UASB Reactor
1. Flow = 45000m^3/day, peak factor = 2.25 peak flow = 3hrs/day. Increased volume = 3*3600*1.302 = 14061.6m^3/day
2. Assume BOD removal efficiency = 40-70% (assumed 45%)
3. Reactor dimension = Total flow (m^3/day)/Up flow velocity (m/hr)
Up flow velocity assumed = 0.7m/hr = 59061.6/0.7*24 = 3515.57 m^3
4. Assumed height = 6meter.
5. Volume = $\pi*r^2*h$
So radius = 13.65 meter
6. Hydraulic Retention time = 6/0.7=8.57 hrs

3.4. Design of Aeration Tank
1. BOD at the inlet of Primary UASBR = 300 mg/l
2. Reduction of BOD in primary UASBR = 45%
3. Therefore, BOD at the outlet of UASBR = 300(100-45)/100 = 165mg/l
4. BOD load to be removed in aeration tank = (165-5) mg/l = 45000(165-5)/1000 = 7200kg/day
5. Maximum temperature =37ºC, Minimum temperature =27ºC
6. F/M Ratio =0.35 (CPHEEO MANUAL Table 13.1)
7. MLSS = 3500 mg/l (CPHEEO MANUAL Table 13.1)
8. Volume of aeration tank based on F/M ratio=7200*1000/0.35/3500 =5877.5m^3 (CPHEEO MANUAL TABLE 13.2)
9. HRT = Volume*24/45000 = 5877.5*24/45000 = 3.13 hours
10. But HRT should be between 4-5 hrs. As per (CPHEEO MANUAL TABLE 13.1).
Assuming HRT = 4.5 hrs
11. For HRT 4.5 hrs. Volume = 4.5*1000*45/24 = 8438 m^3
12. Selector Zone = 15 min
13. Volume for this = 45000/ (4*24) = 469m^3
14. Total volume (V1) = 8438+469 = 8907m^3

Provision for providing MBBR (bio-media)
15. Flow = 45 MLD
16. Flow = 45000m^3
17. Inlet BOD = 165ppm
18. Outlet BOD = 5 ppm
19. Surface Area loading rate = 15g/m^2
20. BOD to be removed in aeration = 160ppm
21. BOD load = 45000*160 = 7200000 g/day
22. Area required = 7200000/160 = 45000m^2
23. Effective surface area of carrier element k1= 500m^2/m^3
24. Percentage media fill = 67%
25. Volume of media (V2) = 45000/500 = 90m^3
Total volume = V1+V2 = 8907+90 = 8977m^3
26. Provide tank depth = 4m
27. Provide 12 tank
28. Area of each tank = 8977/4/12 = 187.02 m^2
29. Consider length of the tank = 15 m, so that the width of the tank = 12.47 m
Although provide width = 12.5m
Hence provide 12 tank of 15m*12.5m*4m LD+0.3m FB

3.5. Design of Air Blower in Aeration Tank
1. Total volume of Tank = 8977m^3
2. Oxygen required in decomposition of 1Kg BOD = 0.9 Kg
3. BOD at inlet = 7200Kg/day
4. BOD at outlet = 20 mg/l/day = 45*5 = 225Kg/day
5. Total BOD removal = 7200-225 = 6975Kg/day
6. Oxygen required under field condition = 6975*0.9 = 6277.5 Kg/day
7. Residual DO in aeration tank = 1.5 mg/l
8. So, Oxygen in aeration tank for DO per day = 8977*1.5/1000 = 13.49Kg
9. Total oxygen needed = 6277.5+13.49 = 6290.99 Kg/day
10. Sp. Wt. of air in summer at 37ºC= 1.14 Kg/m^3
11. Sp. Wt. of air in winter at 27ºC = 1.18Kg/m^3

12. Oxygen content in air = 21%
13. Air required in m^3/day in summer = Total Oxygen needed per day/sp. Wt. /% oxygen= 6290.99/1.14/0.21= 26278.17 m^3/day
14. Safety factor = 1.3
15. Transfer efficiency Maximum value = 0.881(FINE BUBBLE AERATOR)
16. Air required in m^3/day in summer = 26278.17*1.3/0.881 = 38775.96m^3/day
17. So, air required in winter =37461.49 m^3/day
18. Highest value chosen for design = 38775.96m^3/day
19. Air needed in hour = 38820.02/24 = 1615.66m^3/hr
20. We require 1 air blowers for each tank, so in each tank air required= 1562.66/6=269.27m^3/h

Hence provide 12 fine bubble air blowers and 2 stand by

3.6. Design of Clarifier

1. MLSS concentration = 3500mg/ l
2. Design overflow rate = 35m^3/d/m^2 (CPHEEO MANUAL TABLE 12.1)
3. Overflow peak rate = 50 m^3/d/m^2 (CPHEEO MANUAL TABLE 12.1)
4. Surface area for average flow = 45000/35 = 1286 m^2
5. Surface area for peak flow = 59061.6/50 = 1181.23 m^2
6. Solid loading = 45000*3500/1000 = 157500 kg/day
7 .Solid loading rate-average flow = 140 (CPHEEO MANUAL TABLE 12.1)
8. Minimum surface area for this = 157500/140 =1125 m^2
9. Solid loading peak rate = 210 kg/day/m^2 CPHEEO MANUAL TABLE 12.1)
10. Minimum area for this = 59061.6*3500/1000/210 = 984.36m^2
11. Maximum area chosen = 1181.232 m^2
12. If two units are provided then area of each unit =1181.23/2= 590.06m^2

$$\text{Therefore diameter} = \sqrt{A * \frac{4}{\pi}}$$

So, d= 27.40 = 28m

13. Actual surface area = $\pi d^2/4$ So, A= 590.06m^2
14. Provide side water depth = 3.5m

Hence provide 2 No. of 28m dia. * 3.5m SWD+ 0.5M FB

3.7. Design of Pressure Sand Filter

1. Let us consider the HRT of the Activated Carbon Filter = 20 minutes
2. Total flow/day = 45000m^3
3. So, the total volume of the ACF will be 20*45000/ (60*24) = 625 m^3
4. Providing 6 no. of filters, therefore volume of each filter will be 625/6 = 104.16m^3
5. Considering height of the filters be 3m
6. Therefore, Volume = $\pi*r^2*3$, $\pi*r^2$ =34.72, r^2 =11.06, r = 3.33m
7. Therefore diameter of each filter will be 6.66m

Hence provide 6 no. of filters in cylindrical shape each of 3m (height)*6.66m (dia.) + 0.5m FB

The backwashing and rinse process with air blowers will be 1 times per shift.

3.8. Design of Active Carbon Filter

1. Let us consider the HRT of the Pressure Sand Filter = 20 minutes
2. Total flow/day = 45000m^3
3. So, the total volume of the ACF will be 20*45000/ (60*24) = 625 m^3
4. Providing 6 no. of filters, therefore volume of each filter will be 625/6 = 104.16m^3
5. Considering height of the filters be 3m
6. Therefore, Volume = $\pi*r^2*3$, $\pi*r^2$ =34.72, r^2 = 11.06 r = 3.33m
7. Therefore diameter of each filter will be 6.66m

Hence provide 6 no. of filters in cylindrical shape each of3m (height)*6.66m (dia.) + 0.5m FB

The backwashing and rinse process with air blowers will be 1 times per shift.

3.9. Sludge Generations from UASBR

1. Influent TSS = 750mg/l, VSS = 250mg/l (assumed)
2. New Volatile suspended solids produced in BOD removal = yield coefficient*BOD*ή …. **Manohar (1999)**

=0.1*300*0.45

=13.5 mg/l, where ή is the BOD removal efficiency in UASBR.

3. Non-degradable residue = volatile suspended solids*0.6 =250*(1-0.4)

=150 mg/liter

(The non-degradable residue of the VSS coming in the inflow assuming 40% of the VSS are degraded and residue is 60%)

4. Ash received in inflow = TSS-VSS =750-250 =500mg/liter
5. Sludge generated = 13.5+150+500=663.5 mg/liter= 0.663 kg/m^3
6. Total sludge produced = 45000*0.663=29835 kg/day
7. % of dry solids as fraction = 4(As per table 17-4 of GOI manual on sewerage)
8. Volume of sludge = (29835/1000/4)*100 = 745.87 m^3/day

3.10. Excess Sludge (Aeration Tank)

1. Minimum ratio excess sludge kg/kg of BOD removed=0.25(GOI clause 13.4.7)
2. Maximum ratio excess sludge = 0.30
3. Design sludge adopted = 0.3
4. Excess sludge = 0.3*7200 = 2160Kg/day (As per GOI 13.4.7)
5. % of solid concentration = 0.8(As per table 17-4 of GOI Manual on sewerage)
6. Excess sludge = (2160/0.8)*100/1000 = 270m^3/day

3.11. Design of Sludge Thickener

1. Dry solids from UASBR in = 29835kg/day
2. Dry solids from waste sludge = 270kg/day (excess sludge)
3. Total dry solids = 29835+2160= 31995kg/day
4. Solid loading rate = 50kg/day/m^2 (CPHEEO MANUAL TABLE 17.1)
5. Volume of sludge = Excess sludge + UASBR sludge=270+746.4=1016.4 m^3/d
6. Hydraulic loading rate = 24m^3/d/m^2 (CPHEEO MANUAL TABLE 17.2.1)
7. Area required for solid loading = total dry solid/solid loading rate= 639.9m^2
8. Area required for hydraulic loading = volume of sludge/hydraulic loading rate = 42.35m^2
9. Maximum area = 639.9m^2
10. Flow required for hydraulic loading = area required*hydraulic loading rate = 15357.6m^3/day
11. Dilution water for hydraulic loading = flow required for hydraulic loading-volume of sludge = 14341.2 m^3/d
12. Liquid depth of thickener = 3.5m
13. Volume of thickener = area required*depth = 2239.65m^3
14. Provide two tanks
15. Area of each thickener = 319.95m^2
16. Diameter of each thickener= 20.19m

Hence provide two thickener with 20.19 m diameter and 3.5m depth

17. Concentration of underflow solids = 8% (CPHEEO MANUAL TABLE 17.1)
18. Flow to be pumped out of thickener = total dry solid*100/ (concentration of under flow solids*1000) = 400 m^3/d

3.12. Design of Digester

1. Sludge thickener underflow = 400 m^3/d.
2. Detention time in digester = 20days (For a sludge temperature of 20°C, the solids retention time required for 50% VSS)
3. Digester Volume = 20*400 = 8000m^3
4. No. of digesters = 2
5. Provide Liquid Depth = 10m
6. Area for each digester = 400m^2
7. Diameter of each digester = 22.57m
8. Grit allowance = 0.5m
9. Free Board= 0.6m
10. Total liquid depth = 10+0.5 = 10 .5m
11. Total side depth = 10.5+0.6 = 11.1m
12. Dry Solid into digester = TSS removed + Excess Sludge = 29835+2160= 31995 kg/day
13. Solid conc. in feed = Dry solid into digester/sludge thickener underflow = 31995/400 = 80kg/m^3
14. Volatile matter in UASBR sludge = 0.7
15. Volatile matter in excess sludge = 0.85
16. Volatile matter in feed sludge (fraction) = ((volume of UASBR sludge* Volatile matter in UASBR sludge) + (Excess sludge of aeration tank* Volatile matter in excess sludge))/ (volume of UASBR sludge+ Excess sludge of aeration tank) = 0.8114
17. Volatile matter in feed sludge = Dry solids into digester*volatile matter fraction in feed sludge = 31995*0.8114 = 25960.74kg/d
18. Non-volatile matter = dry solids into digester-Volatile matter in feed sludge =31995-25960.74 = 6034.26kg/d
19. Volatile matter fraction digested = 0.50(CPHEEO MANUAL TABLE 17.3)
20. Volatile matter digested = 25960*0.5 = 12980kg/d
21. Undigested matter in sludge = 12980kg/d
22. Total digested sludge = 12980 + 6034.26 = 19014.26kg/d
23 .Concentration of digested sludge = 5%
24. Volume of digested sludge = (total digested sludge/concentration of digested sludge)*100/1000 = 380.28m^3/d

3.13. Generation of Bio-Gas from Digester

1. Bio gas/kg of digested sludge= 0.90m^3/day
2. Gas producing= 0.90*volatile matter digested= 0.90*12980= 11682m^3/day
3. Gas flare capacity=11682/24= 486.75m^3/hour
4. Density of gas=1kg/m^3
5. Gas quantity= 11682kg/day

3.14. Generation of Biogas from UASBR

1. Total COD removed = 50% of incoming load = 0.5(0.4*45000) = 9000kg/day
2. Total Sulphate removal = 50% of incoming load = 0.5(0.085*45000) = 1912.5kg/day

3. COD available for Methane gas production = 9000-1912.5 = 7087.5kg/day
Theoretically methane gas produced at 25ºC = 300L/kg COD removed
Therefore, total methane gas produced per day = 0.3m^3/per kg*7087.5kg per day = 2126.25m^3/day
Practically observed methane gas leaving as dissolved in effluent (in UASBR) = 0.028m^3/m^3 effluent volume per day
Therefore, methane gas leaving = 0.028*45000 = 1260m^3/day
Hence usable methane = 2126.25-1260 = 866.25m^3/day = 866.25/9000 = 0.09625m^3/kg COD

3.15. Power Generation

Power Generation from bio-gas generated from digester

6400m^3 bio gas produces 0.6 megawatt electricity therefore 11682m^3 bio gas will produce 1095.18 kilo watt electricity per day (Jenbacher Type-3 Engine).

Power generation from biogas generated from UASBR

Theoretically, it is known that 1 m^3 biogas with 75% Methane content produce 1.4KWH electricity.
Thus, 866.25m^3 biogas/day = 866.25*1.4KWH electricity = 1212.75 KWH electricity

3.16. Chlorine Contact Tank

1. Detention time = 60 min (assumed)
2. Volume = 50000*60/6525 = 459.77m^3
3. Provide depth = 3.5m
4. Area required = 459.77/3.5= 131.36 m^2
5. Diameter of the tank = d, Area =$\pi d^2/4$, Therefore, 131= $\pi d^2/4$, d= 12.92

Hence, provide 12.92m +3.5m LD +0.5m FB

3.17. Cost estimation for the proposed treatment plant (Treatment Cost)

Power estimation and consumption of the entire treatment process

1. Motor for running bar screen = 2 HP
2. Motor for running detritor = 1.5 HP
3. Air blowers for aeration tank = 52 HP
4. Motor for running scrapper in Secondary clarifier = 2 HP
5. Motor for digester = 7.5 HP
6. Motor for Sludge thickener = 1 HP
7. Motor for centrifuge = 40HP
8. Backwashing of ACF and PSF = 2 HP
9. Lighting = 1HP
10. Chlorine feed pump = 5 HP
11. Motor for lifting the water in UASBR = 40 HP
12. Motor for backwashing of ACF& PCF = 5 HP
13. Power required for Genbacher gas Engine = 70 HP(approx)
14. Miscellaneous = 5 HP
15. Total power consumption = 234 HP
16. Total electricity consumed per day with 20 hrs. Operation = 234*0.746*20 = 3491.28 KWH
17. Total electricity consumed per month = 3491.28*30 = 104738.4 KWH
18. Power generated from biogas of digester = 1095.18 KW per day, therefore with 20hrs. of operation total energy = 1095.18/20 = 54.759 KWH
19. Total electricity produced per month = 54.759*30 = 1642.77KWH
20. Total electricity produced from biogas generated from UASBR = 1212.75 KWH per day
21. Total electricity produced per month from UASBR = 1212.75*30 = 36382.5 KWH
22. Total electricity required = 104738.4- 1642.77-36382.5 = 66713.13
23. Cost per unit = Rs. 5
24. Total Cost = 66713.13*5 = Rs. 333565

Manpower cost

1. No. of Operators required per shift = 2
2. No. of Supervisors required per shift = 1
3. No. of shift = 3, each of 8 hours per day
4. Laboratory Analyst =1
5. Manager = 1

Total Manpower = 11 person

Total cost on manpower
a- Salary to be provided to Operators = Rs. 18000 p.m.
Total salary to be provided to Operators = 6*18000 = Rs. 108000
b- Salary to be provided to Supervisors = Rs. 25000 p.m.
Total salary to be provided to Supervisors = 3*25000 = Rs. 75000

c- Salary to be provided to Laboratory Analyst = Rs. 25000 p.m.
d- Salary to be provided to Manager = 45000
Total manpower cost = 108000+75000+25000+45000 = Rs. 253000

Chemical Cost
1. Chlorine as disinfectant required = 1mg/l
Total chlorine required = 1g/m^3, 1kg/1000m^3, 45kg/45000m^3
Chlorine required per month = 45*30 = 1350kg
Cost of bleaching powder = Rs. 20/Kg
Total cost of bleaching powder = 1350*20 = Rs. 27000
2. Laboratory cost/month= Rs. 70000
Total Chemical Cost = 70000+27000 = Rs. 97000

Miscellaneous Cost = 40000
Total cost = 333565+253000+97000+40000 = Rs. 723565
Total water treated = 45*30 = 1350 ML (Million Liter) per month.
Total water in KL = 1350*1000 = 1350000
Cost of treatment per 1000 liter = 723565/1350000= Rs. 0.54

4. RESULT AND DISCUSSIONS

4.1 Raw Sewage Characteristics

From the above-observed data, it is clear that the domestic sewage treatment plants are “BARA”, “KHARKAI”, ”BURMA-MINES” and “GOLMURI” .their influent BOD varies from 50ppm to 196ppm. Maximum inlet BOD was observed in “BURMA-MINES” it may be because the STP is located near the local drain. The maximum COD value of the domestic sewage was observed in “GOLMURI” ETP, it is because a large number of automobile workshops are present in this area.
The medical effluent ETP “TMH” has high COD and BOD value. The maximum COD value observed was 810ppm and the lowest 237ppm which signifies that the waste from the pathology laboratory constitutes high chemical ingredients and the low value of COD may be due to the effluents generated from the cleaning of the floor, laundry etc. The highest BOD observed was 470ppm, which signifies that the effluent comes from the operation theatres which contain blood, saline, etc.

4.2 Final Effluent Characteristics

From the above-observed tables, it is clear that PSTP which are the conventional type and undergoes biological treatment process and are based on Activated Sludge Process (ASP) does not have high treatment efficiency as compared to different STPs.

1. “Bara” STP final BOD value (average) observed was 13.86 ppm, which is not suitable for any reuse and requires further treatment.
2. Another ASP based STP “Kharkai” its final BOD (average) observed was 10.93 ppm regarding this value the reuse of the effluent could be done.
3. Whereas MBBR- technology-based treatment plants “Golmuri”, “TMH”, “Puri”, have high BOD, COD removal efficiencies. Showing final BOD as 9.68, 7.88, 6 ppm respectively, and COD value as 30.88, 40.94, 27.5 ppm respectively. The final effluent generated is of better quality.
4. The medical effluent treatment plant “TMH”. It has high treatment efficiency and horticulture and washing of streets is preferred from the treated wastewater.
5. The “Pejo-Nala” plant, Puri, treats the rice water effluent coming from Jagannath temple, Puri. Its inlet BOD is as high as 30000mg/l and COD value is also high as 30000mg/l, and the average outlet BOD is around 6 mg/l and average outlet of COD is 27mg/l. Having overall treatment efficiency of more than 99%. It is because of having a very complex treatment and having additional filtration process i.e. Micro-Filtration and the treatment is based on MBBR-technology. Its effluent can be used as artificial pond recharge, groundwater recharge, horticulture, etc.
6. And anaerobic sludge digestion based sewage treatment plant “UASBR-Burma mines” it has high BOD, COD removal efficiency without going any complex process. It is because of the presence of an “UASB-Reactor” which digests the organic matter very efficiently and generates very low sludge as compared to other treatment processes. Its treated water could be used in gardening.

4.3 Wastewater Reuse Option in Jamshedpur City

Present reuse: As it is very necessary to make the reuse of the treated wastewater otherwise the treatment will be meaningless and after the reuse, the freshwater demand will be less and hence the water balance will be maintained.

Table 5 shows the current final disposal point of treated effluent. Presently about 220 hectare of land is available for irrigation, horticulture, gardening, etc.

Table 5: Disposal of effluent from existing STPs

Name of STP	Final disposal point	% Reuse	Treatment required + potential reuse option
STP, Kharkai	Jubilee park, Jayanti Sarovar, Kharkai river	70	Tertiary treatment + industrial reuse
STP, Bara	TATA STEEL, Swarnrekha river	25	Tertiary treatment + irrigation reuse
PSTP, Golmuri	Golmuri golf course, local fountain	100	No treatment required + gardening reuse

ETP, TMH	TMH local fields	100	Extended chemical dosing + gardening reuse
UASBR-Burmamines	Burma mines pump station garden	100	No treatment required + irrigation use
ETP, TATA Cummins	TATA Cummins local fields, flowering gardens	100	Chemical treatment + industrial use
ETP, PEJO-NALA, PURI	Local pond	100	No Treatment required + irrigation reuse

The final effluent from "Kharkai" STP is now presently used for watering in "Jubilee Park", recharge of "Jayanti Sarovar" pond, watering in the fields of "Kennan Stadium" and "JRD sports complex and the rest 25% of the treated water is disposed of in "Kharkai River". More effective reuse of the effluent can be done with some modification in the treatment plant as recommended. The final effluent from "Bara" STP is reused in "TATA STEEL" and the rest 75% of water is disposed of in "Swarnrekha River". It requires modification in the treatment plant to produce better quality effluent so that its effluent could be used as major horticulture and for reuse in irrigation (restricted and unrestricted). Vaidya et al. (2003) reported increased Risk of Hepatitis E in sewage workers from India suggesting that strict adherence to good working practices must take top priority for the protection of these workers from sewage pathogens. World Health Organization (WHO) recommended standards form microbiological Quality of treated wastewater when used for restricted irrigation is BOD <10mg/l, COD<60mg/l, TSS<10mg/l. Thus, based on these guidelines and research outcomes, the final effluent from all STPs majorly "Kharkai" and "Bara" STP shall pose risk to public health. So, direct reuse is not possible before improving the quality of the effluent. From the present study, it is evident that the potential usage of the treated effluent in Jamshedpur city is for irrigation, horticulture, industrial use, recreation. Thus to mitigate public health risk, it is mandatory to employ tertiary treatment unit employing disinfection, if reclaimed water is to be used for unrestricted irrigation, recreation, irrigation reuse and for artificial recharge.

5. CONCLUSIONS

In the study of the wastewater treatment plants in Jamshedpur, it was concluded that the treatment plants in Jamshedpur are designed in such a way that it treats the sewage up to a certain level that is not worthy for reuse in domestic purpose it can only be disposed of in rivers, used barely in industries and agriculture. As per the current situation in the city, saving the water and making the potential reuse of the treated sewage is much necessary, a certain change in the current treatment process will definitely be the solution and the idea for the proposed treatment process will be highly beneficial for making reuse of the treated sewage in the city.

The treatment plants which are under "JUSCO Ltd." have good treatment capacity and most of the treated water from the STPs, PSTPs, and ETPS has reuse option. Treatment plants with "MBBR" technology and "UASBR" technology were much more efficient than conventional "ASP" based STPs. "BIOFORE" process based ETP "TATA Cummins" showed moderate treatment. Presently about 40.196 MLD wastewater is being treated and about 14.646 MLD is being reused in the local area. But the biggest treatment plant of Jamshedpur "BARA", with the treatment of about 30MLD its effluent, is currently being used in industrial reuse but it may be used in agriculture use after the treatment process is modified. In this city, the water can be reused in many options largely in industry and agriculture. The guidelines for industrial reuse of wastewater effluent do not exist in India; therefore these should be introduced and implemented for sustainable reuse of wastewater. The efficiency of the MBBR-treatment process based treatment plant "Pejo-Nala (Puri)" was the best in the total study. It was because of having a very good treatment process and having a microfiltration in it. Implementation of micro-filter in a sewage treatment plant is a good idea but the treatment cost will increase by many times. So, it is preferred to be installed in PSTPs to recycle the wastewater.

UASB-Reactor is a very good idea for reducing the BOD and COD load as it generates very less amount of sludge and it showed very good treatment efficiency. And in MBBR technology the increased numbers of bacteria were present due to the plastic media. The idea is very good to implement in the treatment plants to improve the treatment efficiency.

"Burmamies" plant was found to be the best sewage treatment plant as it showed high treatment efficiency without any complex process and it has also very low maintenance and operation cost but the initial investment is much higher and sometimes after the treatment, it may produce odour nuicance.

The treatment cost of all the STP is much higher than the proposed treatment scheme and also have low treatment efficiency, so it is recommended to make a change in the current treatment process to make it work better and give good final effluent.

Thus, further change or modification in the treatment process will increase the treated wastewater reuse and the water. This will be really beneficial in the present time to save the fresh water and reduce the raw water extraction from the rivers of Jamshedpur. The design proposed in the study will be very beneficial for the modification process in the "Bara", "Kharkai" treatment plant.

6. REFERENCES

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