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Conceptual Design of a Wastewater Treatment Plant for the Dera Bassi Industrial Estate, Punjab (India)

By Farid Ansari & Yashwant K. Pandey

PDM College of Engineering, India

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CONCEPTUAL DESIGN OF A WASTEWATER TREATMENTPLANT FOR THE DERA BASSI INDUSTRIAL ESTATE, PUNJABINDIA

Strictly as per the compliance and regulations of :

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Farid Ansari [α] & Yashwant K. Pandey [σ]

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I. Introduction

An industrial estate is a composition of several different types of industries located in one area, each producing effluent is of varying wastewater characteristics. In a scheme of unplanned development, it is a common practice for each company on an industrial estate to develop their individual effluent treatment plant. When the industrial estate is considered as a whole, one observes that, because of this practice, valuable resources are wasted on effluent treatment. These resources include capital cost, land space and maintenance costs. A common effluent treatment plant and industrial ecology offer an alternative to the practice of having individual effluent treatment systems and makes better overall use of the resources of an industrial estate.

Developing low cost technology for wastewater treatment offers an alternative and has been found to be most effective for treatment of domestic and industrial wastewater, particularly for those situated in the tropical and subtropical regions (NgMiranda et al. 1989; Puskas et al. 1991; El-Gohary et al. 1995; Rosen et al. 1998). Technologically because of the simplicity of waste stabilization ponds even affluent nations, which can afford the luxury of expensive wastewater treatment, are planning to use more and more low cost treatment technologies (Khan and Ahmad, 1992; Junico and Shelef, 1994). Damian et al. (2006) analyzed the long-term dynamics in the development of a wastewater treatment Plant. Whereas Shubhra et al. (2011) studied the process design for decentralized sewage treatment system with total natural resource management. Level of wastewater pollution varies from industry to industry depending on the types of processes and the size of the industry (Garcia et al., 1995). Wastewaters that are generated from different sites represent different wastewater generation patterns, flows and constituents (Hii, 2008).

Punjab Small Industries and Export Corporation limited (PSIECL) was established in 1962 with the objective of supporting the individual in his endeavor to set up his own industrial unit and help him and the small-scale industry to grow in Punjab. PSIECL has been acting as a Catalyst & springboard for all round development and promotion of industries in Punjab through the development of Industrial infrastructure, namely Industrial Focal Points (IFP) ranging between 50 acres to 500 acres of land at various towns and cities of Punjab. Therefore to facilitate the spirit of industry, PSIECL provides self-sufficient industrial focal points. These industrial hub, consist of developed plots equipped with power substations & distribution networks, telecommunication facilities, residential area for workers, common effluent treatment plants and parts for the clean environment.

As per the regulatory norms and instructions by pollution control board, the water polluting industries have to set up their own effluent treatment plants to meet the surface water discharge standard before sending into the common sewer line. The industrial as well as domestic wastewater from the individual industries are being discharged (after requisite treatment) to the common sewer line and presently discharged into the nearby canal without any treatment. PSIECL has a distribution network of raw materials across Punjab. It is the handling agency of SAIL, MMTC, IISCO, HZL, HCL. It is also First State Corporation to get

Author α : Department of Applied Science and Humanities, P.D.M College of Engineering, Bahadurgarh, (Haryana), India.
Author σ : School of Energy and Environmental Studies, Devi Ahilya University, Indore (M.P), India.
e-mails: checkfarid@gmail.com, yashwantkpandey@gmail.com

itself accredited by Joint Accreditation system of Australia and New Zealand (JAS-ANZ) under ISO-9001. Dera Bassi Industrial Estate is spread in about 150 acres and having more than 200 different sized plots for the Industrial Purpose. Presently,115 numbers of industries are functional and 12 numbers of industries are non-functional. The remaining plots are vacant which have already been allotted to the entrepreneurs for setting of the industries.

This project aims to develop the conceptual design of an effective and economically responsible wastewater treatment plant for the PSIECL. The plant will use as many sustainable and energy efficient concepts as possible, while still keeping construction and maintenance costs low. The over-arching goal of the project is to prevent the contamination of the aquifer, while also minimizing the environmental impacts on the surrounding ecosystems. The design process includes taking into account the advantages and disadvantages of different unit processes, analyzing their technical details and determining the removal efficiency of each unit operation.

II. Study Area

Dera Bassi municipal council, Mohali district, Punjab, is located on the National Highway No.22, (Chandigarh-Ambala-Delhi Road), 20 km from Chandigarh. It is strategically located near the boundary of Haryana, Himanchal Pradesh and Union territory of Chandigarh. The site Focal Point – Phase II is situated near 100 meter distance of industrial focal point of PSIEC, Dera Bassi. The industrial focal point of Dera Bassi starts at the northern part of Dera Bassi bounded by the Mubarikpur and Mirpur villages along the Old Kalka Road. Hence, it has been observed that more prominent industrial developments exist and are in full operations. Dera Bassi Industries Association was formed to help overcome the obstacles that the industries in this area had to face and arrange for facilities like well paved roads, water supply, affordable goods transport and proper lighting etc. from government agencies and to cater to the demand for good industrial environment.

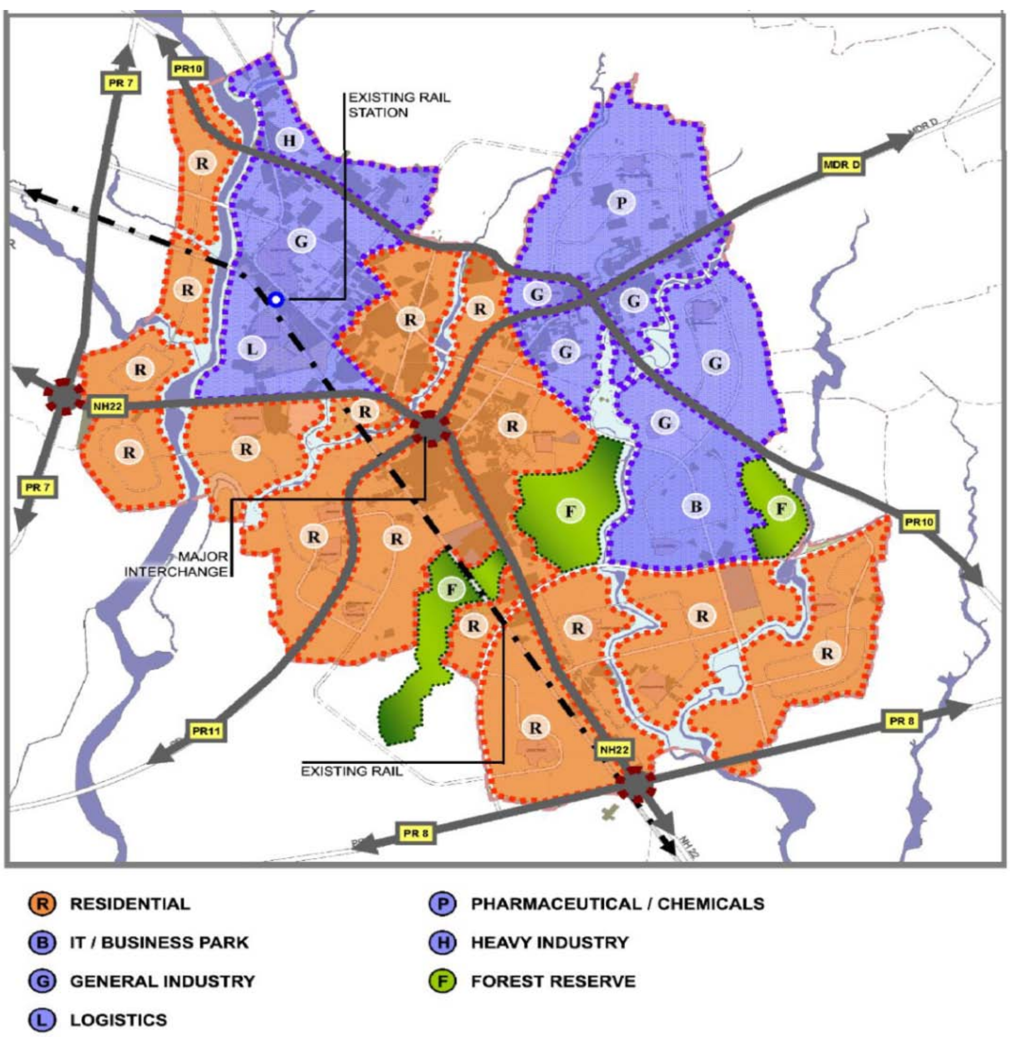

Figure : 1 Study area of the Derra Bassi

III. Materials and Methods

Wastewater samples were analyzed in accordance with the procedure laid down in standard methods for the examination of water and wastewater (APHA, AWWA 2005). Designing of wastewater treatment procedure depended on the inlet quality of effluent. The various principles and rational, scientific as well as empirical formulae used in the design of the treatment units were derived from standard references, hand books and manuals of American Society of Civil Engineers and Central Public Health and Environmental Engineering Organisation.

IV. Result and Discussion

The result and discussion is divided into two parts, first part deals with the study of wastewater which was continuously discharge from Dera Bassi industrial estate and the second part deals with the conceptual design of the wastewater treatment plant.

a) Collection of Wastewater Sample and Analysis Results

Composite combined wastewater samplings have been collected for 24 hours for seven days and the same have been analysed in the laboratory for the relevant parameters. The analysis results are placed in table 1.

Table 1 : Results of Combined wastewater sample

Parameters	Units	Sample 01	Sample 02	Sample 03	Sample 04	Sample 05	Sample 06	Sample 07
pH	–	6.2	6.4	6.5	6.1	6.3	6.2	6.4
Colour	–	yellow	yellow	Yellow	Yellow	yellow	Yellow	yellow
Oil and grease		15	19	16	25	29	32	38
EC	US	1956	2342	2079	2064	2169	2579	2289
Turbidity	NTU	12	15	18	13	16	18	22
Total Suspended Solids	mg/l	653	659	702	715	720	698	740
Total Dissolved Solids	mg/l	1712	1820	1900	1799	1786	1894	1942
Biological Oxygen Demand	mg/l	1159	1283	1169	1243	1320	1349	1284
Chemical Oxygen Demand	mg/l	2210	3320	3120	2389	2486	2512	3100
Lead	mg/l	0.05	0.05	0.08	0.06	0.07	0.06	0.07
Cadmium	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	mg/l	0.15	0.14	0.16	0.11	0.13	0.12	0.14
Zinc	mg/l	0.45	0.58	0.34	0.67	0.59	0.12	0.67
Chromium	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/l	1	2.3	1	2.45	2.1	1.56	1.92
Iron	mg/l	7.4	7.9	8.3	8.2	7.7	8.5	8.3
Cyanide	mg/l	0.05	0.01	0.021	0.18	0.21	0.05	0.06
Arsenic	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium	mg/l	78	79	78	79	77	76	78
Calcium	mg/l	80	90	70	80	80	80	130
Chlorides	mg/l	320	374	370	360	329	365	354
Nitrates	mg/l	80	66	51	54	71	77	69
Sulphates	mg/l	168	374	290	190	321	262	301
Total Nitrogen	mg/l	20	40	55	38	45	49	52
Total Alkalinity	mg/l	150	250	290	301	168	252	220
Total Hardness	mg/l	400	500	350	460	500	450	470
Sodium	mg/l	150	170	197	184	169	154	192

b) Design of wastewater treatment plant

The design of the wastewater treatment plant is divided into the units of Inlet chamber, Screen chamber, Grit Removal Unit, Equalization Tank, Clari-Floculator, Aeration Tank, Sand Gravity Filter and Sludge Drying Beds *etc.*

i. *Design flow and characteristics*

The combined wastewater generated from various industries is being conveyed through the sewer line to the receiving end of the Proposed STP site. The design flow and characteristics of wastewater for the treatment in the proposed STP is placed below in table: 2.

Table 2 : Design flow and characteristics of waste water

Description of Parameter	Value	Unit
Quantity of Sewage Generated	4000000.00	Lpd
	4.00	MLD
	4000.00	Cum/day
Raw Sewage Characteristics		
Average Effluent flow entering the treatment plant	4000000.00	Lpd
Assumed Peak Factor	1.20	
Peak Effluent flow entering the treatment plant	4800000.00	Lpd
COD	3000.00	mg/l
BOD	1500.00	mg/l
TDS	1800-2000	mg/l
TSS	750.00	mg/l
pH	6.50	

ii. *Treatment scheme and size*

Based on the data collected by field visit & research available from the industries on hydraulic load distribution a composite sample was prepared for carrying out laboratory scale treatability study to fix treatment scheme. STP will be compact, smell free and consume less power with best treatment scheme. The process flow diagram for the treatment of wastewater in the proposed STP is placed at **figure - 1**.

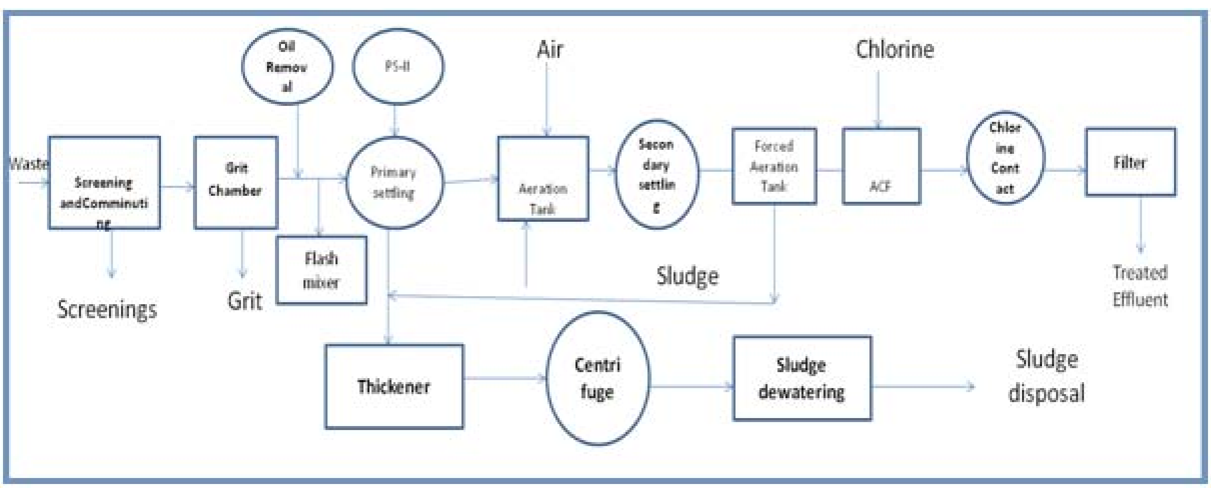

Figure : 2 Process flow diagram for the treatment of wastewater

iii. *Inlet chamber*

The combined wastewater will be passed through the Inlet Chamber. The inlet chamber has been designed for peak flow of 4800 cum/day. The design detail is placed in **table 3**:

Table 3 : Design detail of Inlet Chamber

Quantity of Flow (Ave)	4000.00	Cum/day
Peak Flow	4800.00	Cum/day
	0.06	Cum/Sec
Assumed Detention period	10.00	sec
Volume of the Inlet Chamber	0.56	Cum
Assumed Depth of flow	0.60	M
Area Required for Inlet Chamber	0.93	Sq.m
Assumed Length to Breadth Ratio	1.00	
Breadth of the Tank	1.00	M
length of the Tank	1.00	M

(Provide the Dimension of Inlet Chamber as 1 m x 1 m x 0.6 m SWD + 0.3 m Freeboard)

iv. *Screen chamber*

The wastewater from Inlet chamber will flow by gravity to the screen chamber for the removal of floating material. The design detail is placed below in **table 4.**

Table 4 : Design detail of screen chamber

Peak Design Flow	0.06	cum/s
Assume Clear spacing between bars, o	6.00	mm
Velocity ahead of screen (Va)	0.60	m/sec
Area of Screen Channel, A= (Q/Va)	0.09	m^2
Keeping Side Water Depth	0.50	m
Width of each screen channel, W	0.20	m
Water depth upstream, ha = A/W	0.45	m
T	0.01	m
Number of openings in chamber, W = X.o + (X - 1).t where , X = No. of Opening ; o = Clear Space between bars ; t = Thickness of flat	13.00	no
Total width of opening, Ws =x*o	0.08	m
Assume Angle of inclination	60.00	degree
Assumed Detention Period in the Screen channel	6.00	sec
Assume Length of the screen chamber	3.60	m
Inclined height of the screen, H1	0.52	m
Say		
Velocity through the screen, Vs= Q/H1*Ws	1.37	m/sec
Head loss thru screen in normal condition, h1=0.0729(V_s^2-Va^2)	0.11	m
Head loss on 50% clogging h1=0.0729(2*Vs^2-Va^2)	0.25	m
Water Depth downstream Hb, (Za-Zb)+Va^2/2g-Vs^2/2g+Ha-Headloss thru screen in normal condition	0.26	m
Water Depth downstream Hb, (Za-Zb)+Va^2/2g-Vs^2/2g+Ha-Headloss thru screen in clogged condition	0.12	m

(Provide the Dimension of Screen Chamber as 3.6 m x 0.2 m x 0.5 m SWD + 0.3 m Freeboard)

v. *Grit Removal Unit*

The screened wastewater from screen chamber will flow by gravity to the Grit Removal Unit for the removal of grit, sand and silt. The design detail is placed below in **table 5:**

Computation of Settling Velocity: Stoke's Law		
Kinematic Viscosity of Effluent assumed	0.0000011	sqm/sec
Particle Diameter assumed	0.000150	m
Settling Velocity	0.02	m/s
Reynold's number, Re=(d.Vs/Kinematic viscosity)	2.73	
for Transition flows, Vs=$[(0.707(Ss-1)d^{1.6}v^{-0.6})]^{0.714}$	0.02	m/s
Actual Setling velocity	0.02	m/s
removal efficiency	1474.07	cum/sqm/d
Assumed Removal Efficiency	75.00	%
	1105.55	cum/sqm/d
Actual Surface Over Flow Rate :(Q/A)= $V_s n/[(1-\eta)^{-0.125}-1]$	974	cum/sqm/d
Dimensions of grit channel:		

Table 5 : Design & dimension of Grit Removal unit

Peak Flow	4800.00	cum/day
Total Plan area of Grit channel = Qpeak/(Q/A)	4.93	m^2
Assumed Width of the Grit channel	2.50	m
Length of the Channel	2.00	m
Liquid Depth assumed	1.50	m
Provide a depth for the Grit Storage	0.30	m

(Provide the Dimension of Grit Removal unit as 2 m x 2.5 m x 1.5 m SWD + 0.3 m Freeboard)

vi. *Equalization Tank (Collection Chamber)*

The wastewater from Grit Removal Chamber will be collected in the Equalization or Collection Tank so homogenization of the waste water. The design detail is placed below in **table 6.**

Table 6 : Design and dimension of Equalization Tank

Peak Design Flow	4800.00	Cum/day
Assumed Detention period	*4*	hours
Volume of the Tank	*800*	Cum
Assumed Depth of Liquid column	*5*	m
Area required for the equalization tank	*160*	Sq.m
No. of Tanks Proposed	*2*	
area required for each equalization tank	*80*	Sq.m
Length to Breadth ratio	*1*	
Breadth of the tank	*9*	m
Length of the tank	*9*	m

(Provide the Dimension of Equalization Tank as 9 m x 9 m x 5 m SWD + 0.3 m Freeboard)

vii. *Raw Sewage Pump (Transfer Pump)*

The wastewater from the equalization tank will be puped through centrifugal pump to the Clari-floculator for the settling of suspended particle after removal of Oil & Grease and treatment with Chemical. The design detail is placed below in **table 7.**

Table 7 : Dimension detail of Effluent Transfer Pump

Type of Pumps - Submersible/Horizontal Centrifugal		
Average flow	4000.00	Cum/day
Number of working hours	20	hrs
Flow Capacity of Pump required	200.00	Cum/hr
Proposed pumps 4numbers (2W + 2SB), flow per Pump	100.00	Cum/hr
	27.78	lps
Head required	14.00	m
HP required for pump	10.50	hp

viii. *Clari - Floculator*

The wastewater from after treatment with chemical in the flash mixer will be allowed for settling in the Clari-floculator where the suspended particles would be settled. The supernatant will go for the biological treatment in the aeration tank whereas the settled sludge will be send to the thickener for dewatering of sludge and finally disposal into the secured place. It is expected that 40 to 50% reduction in COD and BOD shall be achieved in physico chemical treatment of the industrial waste water. The design detail is placed below in **table 8.**

Table 8 : Design detail of Clarifier

No. of Tanks 2		
Average Flow in each tank	2000.00	cum/day
SOR	25.00	Cum/Sqm/day
SWD	2.00	m

Solid conc. In settled sludge -%	0.8 to 0.9	%
Area Required for the Tank	80.00	Sq.m
Diametre Required for Secondary Settling Tank	10.09	m
Assumed Detention Period	3.10	hrs
	258.33	Cum
Depth of the Clarifier assumed	2.50	m
Area of the Clarifier	103.33	Sq.m
Provide Secondary Clarifier of Diameter	11.50	m
Surface Loading Rate	19.35	Cum/Sq.m/day
Assumed BOD reduction in Clarifier	20.00	%

(Provide the Dimension of Clari-floculator as 11.5 m diameter x 2.5 m SWD + 0.5 m Freeboard)

ix. *Aeration Tank/ Secondary Tank/ Secondary Clarifier/ Forced Aeration Tank*

The wastewater will be allowed for biological treatment in the Aeration tank and forced aeration tank. Air would be supplied through the Surface Aerator. The excess sludge would be settled in the Secondary Clarifier. The settled sludge would be treated in the thickener and after dewatering & drying, it would be disposed in the designated location. The different mode of biological treatment would be worked out for achieving the regulatory norms.

x. *Treated Sewage Sump*

The treated wastewater would be transferred through pump from the Treated Sewage Sump. The design detail of the sump is placed below in table 9.

Table 9 : Dimension of Treated Sewage Sump

Assumed Detention time	15.00	Minutes
Average Flow	4000.00	Cum/day
Volume of the tank	41.67	Cum
Provide a depth of tank	4.00	m
Area of the Tank	10.42	Sq.m
Square tank Size	3.20	m

(Provide the Dimension of Treated Sewage Sump as 3.2 m x 3.2 m x 4 m SWD + 0.3 m Freeboard)

xi. *Rapid Sand Gravity Filter*

The treated water will be passed through the Rapid Sand Gravity Filter/ Activated Carbon Filter for the removal of the fine suspended particles and colouring material. The design detail of Rapid Sand Gravity Filter and Filter feed pumps are placed below in table 10:

Table 10 : Dimension of Rapid Sand Gravity filter

Average Flow	4000.00	Cum/day
Filter Operating hours	20.00	Hrs
Operating flow	200.00	Cum/hr
Filter Loading rate	6.00	Cum/hr/Sq.m
Area of the Filter required	33.33	Sq.m
Filter bed required	8.333333333	
Each size of the Filter bed Required	3.30	M

(Provide 4 no.s the Dimension of Rapid Sand Gravity Filter as 3.3 m x 9.5with 2.5 m Shell height)

xii. *Chlorination*

The treated water is further contact with Chlorine for the disinfection of treated water. The design detail is as follows:

Table 11 : Detail of Chlorine dosing

Disinfection through Chlorination		
Bleaching powder Dozers, 1W+1SB	3500.00	litres/hour
or Vacuum Chlorinator 1 W+1 SB	1.00	Kg/hour
Chlorine Contact tank 15 minute detention	8.1*8.1*4	m*m*m

xiii. *Sludge Dewatering/ Filter Press/ Sludge Drying Beds*

The sludge generated from primary and secondary clarifier would be dewatered through the filter press and subsequently the sludge is dried in the Sludge Drying Beds. The design detail of the Sludge Drying Bed is placed below in the **table 12.**

Table 12 : Dimension of Sludge Drying Beds

Filter press for Sludge Disposal to handle sludge off	2400	kg/day
	228571.43	Cum/day
	1904.76	Cum/hr
OR		
Population Equivalent	30000.00	Persons
area per person	0.03	Sq.m
Total Area required	750.00	Sq.m

(Provide Sludge Drying Beds of Size 16 m x 16 m x 1.8 MTRS -20 No.)

xiv. *Size of Sludge and Sewer Lines*

There are two types of sludge dewatering systems which can be installed: Sludge Drying Bed (Conventional based on natural drying) Mechanical Dewatering System. In this equipment sludge will be filtered in plate and frame type dead end filter. From filter press sludge shall be available in form of Wet Cake having 25% to 35% solid content. Filtrate shall be taken back to effluent treatment plant. Sludge cake shall be packed in bags and shall be stored in hazardous waste storage area for disposal and treatment. The sludge and sewage lines are placed below in the **table 13.**

Table 13 : Dimension of Sludge & Sewage line

Pipe Sizes (Diameter in mm)		
Gravity Lines		
Sludge line	160.00	mm
Sewage line	125.00	mm

xv. *Hydraulic Calculation*

In order to get the hydraulic profile of the various components of the STPs, the relevant calculation is placed in **table 14.**

Hydraulic Calculations		
Average Ground Level	100.00	m
Inlet Chamber		
Water Level in the Inlet Chamber be	200.00	m
Liquid Depth Provided in the Inlet Chamber	0.60	m
Bed Level of Inlet Chamber	199.40	m
Bar Screen Chamber		
Water Level in the Bar Screen Chamber be	199.35	m
Bed Level of U/s of Bar Screen Chamber	199.09	m
Bed Level of D/s of Bar Screen Chamber	198.84	m
Grit Chamber		
Water Level in the Grit Chamber be	198.74	m
Bottom Level of Grit Chamber	197.24	m
Silt Depoition Hopper bottom level	196.94	m

Equalization Tank		
Water Level in the Equalization tank	198.24	m
Bed Level of Equalization tank	193.24	m
Secondary Clarifier		
Water Level in the Secondary Clarifier	197.84	m
Bottom Level of secondary Clarifier	195.34	m
Treated Sewage Sump		
Water Level in the Sump	196.84	m
Bed Level of Treated Sewage Sump	192.74	m
Wall Top Level of Treated Sewage Sump	100.50	m
Pump House		
Size of the Pump House	100	Sq.m
Finished Floor Level of the Pump House above Treated Sewage Sump	100.65	m
Roof Bottom Level of Pump house	104.00	m

V. Conclusion

Wastewater treatment plays an important role in water pollution control. Proper design, operation and maintenance only can give good removal efficiency of pollutants. The actual implementation and maintenance of this scheme will give proper idea of process handling and actual benefits. Through this project, it has been shown that it is feasible to have a common effluent treatment plant for an industrial estate. The conceptual design of the wastewater treatment plant described in this report is a very essential part of addressing current pollution problems. All the proposed treatment units were designed to achieve acceptable effluent characteristics in compliance with the national standards, using the least expensive, most traditional, and energy efficient technologies available.

References Références Referencias

1. APHA, AWWA and WEF. (2005). Standard methods for the examination of water and wastewater, 21st edition. Port City Press, Baltimore, Maryland, USA.
2. American Society of Civil Engineers and The Water Pollution Control Federation. Sewage Treatment Plant Design, New York, 1959.
3. Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development. Manual on Sewerage and Sewage Treatment, New Delhi, 1993.
4. Damian Dominguez, Willi Gujer, (2006) Evolution of a wastewater treatment plant challenges traditional design concepts, Water research, 40, 1389 – 1396.
5. El-Gohary, F. A., Abou-Eleha, S. I. and Aly H. I. (1995) Evaluation of biological technologies for wastewater treatment in the pharmaceutical industry. Water Science and Technology.32 (11): 13-20.
6. Garcia, A.,Rivas H. M., Figueroa, J. L. and Monroe A. L. (1995) Case history: Pharmaceutical Wastewater treatment plant upgrade, Smith Kline Beecham Pharmaceuticals Company., Desalination 102(1-3): 255263.
7. Hii, L. C. (2008) Characterization of wastewater and storm water for small sites. BEng, Curtin University Sarawak Campus.
8. Junico M. and Shelef G. (1994) Design operation and performance of stabilization reservoir for waste water irrigation in Israel. Wat. Res. 28: 175-186.
9. Khan M. A. and Ahmad S. I. (1992) Performance evaluation of pilot waste stabilization ponds in subtropical region, Wat. Sci. Tech. 26: 1717-1728.
10. NgMiranda W.J, Yap G. S. and Sivadas M. (1989) Biological treatment of a pharmaceutical wastewater. Biological Wastes. 29(4): 299-311.
11. Puskas K., Essen I. I., Banat I. and Al-Daher R. (1991) Performance of an integrated ponding system operated in arid zones. Wat. Sci. Tech. 23:1543-1542.
12. Rosen M., Welander T., Lofqvist A., and Holmgren J. (1998) Development of a new process for treatment of a pharmaceutical wastewater. Water Science and Technology. 37(9): 251-258.
13. Shubhra Singh, N. Janardhana Raju and Gyan Sagar, (2011) Process design for decentralized sewage treatment system with total natural resource management. International Journal of Water Resources and Environmental Engineering Vol. 3(11), pp. 233-237.

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