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Study of Shefrol - An Eco Friendly Bioreactor used for Wastewater Treatment of Udgaon Village

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Abstract:- The use of aquatic plants to treat wastewater is increasing due to its low operation and maintenance cost. In addition it is eco-friendly easy to construct and can be dismantled easily. The Udgaon village doesn't have any management for wastewater disposal. They directly mix the wastewater into natural resources or directly used for irrigation purpose which is not good. In this project, I have used two aquatic plants i.e, Cyperus rotundus L and Ipomoea aquatica and a system with emergent type is constructed called as SHEFROL (Sheet flow root level) system. For Domestic wastewater, It is seen that the removal efficiency of pH is 11.71% in both pre and post-monsoon season and for TS, TDS, TSS, DO, BOD, COD, nitrate, potassium, phosphorus, oil and grease are 34.66 %, 33.97%, 50%, 60%, 37.18%, 53.25%, 33.86%, 40.8%, 56.76%, 39.83% respectively during post-monsoon season and during pre-monsoon season it is 34.26%, 34.29%, 37.5%, 62.5%, 38.22%, 55.17%, 35.92%, 39.19%, 60.65%, 39.68% respectively. For industrial wastewater, it is seen that the removal efficiency of pH, TS, TDS, TSS, DO, BOD, COD, nitrate, potassium, phosphorus, oil and grease and Heavy metal-Zinc are 29.61%, 34.66%, 33.97%, 50%, 60%, 37.18%, 53.25%, 33.86%, 40.8%, 56.76%, 39.83% , 33.33% respectively during post-monsoon season.

Key words: Wastewater treatment., aquatic plants, SHEFROL system, phytoremediation

1. INTRODUCTION

In the early days of sanitary engineering, natural treatments such as soil filter, constructed treatment wetlands and waste stabilization pond were the only method known. Initially, treatments were not even an objective, nor were the processes understood. Wastewater was simply disposed of in the nearest river, lake, or swamp if one was available. As the communities grew, the carrying capacity of the receiving water was eventually exceeded and problems began to arise in terms of aesthetics, public health, environmental effects, or, more commonly, a combination of the three. The need for treatment prior to discharge was recognized at this point and primary treatment was developed to remove most of the larger solids and organic matter. Natural systems were more or less forgotten because they had not performed well under the required loads. As understanding of the environment, disease causing agents, and treatment processes increased the complexity of the treatment processes also increased to remove higher and higher percentages of the pathogens and contaminants of concern. The cost of treatment unfortunately increased as well and continues to do so even in the absence of further increase in treatment complexity. The Clean Water Act further aggravated the problem by requiring secondary treatment at many sites that had not previously used that level of treatment. Natural treatment systems came back into consideration mostly as an attempt to find a more cost effective means of achieving the mandated treatment levels than was available with the existing mechanical or chemical processes. Natural treatment systems are not disposal practices nor are they random applications of waste and wastewater in various habitats. Natural treatment systems are engineered facilities which utilize the capabilities of plants, soils, and the associated microbial populations to degrade and immobilize wastewater contaminants (Bruce Alan Hastie, 1992).

The two main categories of natural treatment system are land treatment and aquatic treatment systems. Each category can be further subdivided based upon the type of application and the types of plants used. Land treatment is the application of wastewater or wastewater sludges to the soil and allowing the plants and soil matrix to remove contaminants. Land treatment is divided into land farming slow rate irrigation, rapid infiltration, and overland flow treatment systems. These treatment schemes are not within the of this report and as such will not be mentioned any further herein (Bruce Alan Hastie, 1992).

Aquatic treatment involves passing wastewater through either wetlands or other aquatic plant ecosystems, whether natural or man-made. Removal of contaminants takes place by plant uptake, microbial degradation, filtration, chemical precipitation and sedimentation. Wetlands systems are designed around emergent aquatic plants (macrophytes) and can be divided into subsurface flow systems and free water surface systems. The two main categories of aquatic plant systems are floating aquatic plant and submerged aquatic plant systems. Aquatic plant systems take on a variety of forms and use many different species of plants. Several flow schemes have been tried as well as many variations on the varieties of plants used and

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the amount of plant harvest performed. Conflicting opinions on the contribution of the plants themselves to the treatment have resulted in widely varied design approaches.

The Aquatic plants used are act as low-cost extraction devices to purify polluted water. In some cases plants decomposes waste faster than micro-organisms. The aquatic plants are capable of reducing the values of BOD, COD, turbidity,odor etc.(Gian 1980) to a concentration required by national and local guidelines as well as international standards for irrigation water.As in rural area, it is very difficult to practice treatment plants due to economic and space concern .Also skilled labors are required to operate other treatment plants. Hence it's required to seek out economical and economical substitute for such treatment plants that ought to be eco-friendly.The aquatic plants that don't need any energy consumption. It can be adopted in rural areas where conventional treatments methods cannot be used due to economic and space concern,. It is an eco-friendly type of system and hence has greater scope in nearby future and can be proved as a beneficial substitute for conventional methods.

In this project, I have used two aquatic plants namely Cyperus rotundus L and ipomoea aquatica are extremely tolerant and has capacity for uptake of heavy metals from MIDC around udgaon village including, Zn(mg/l),which could make it suitable for bio cleaning of industrial wastewater.The plants eliminate disturbing smell of wastewater which poses serious problem in location throughout Udgaon village. The aquatic plant system offers an environment friendly and cost-effective technology for treatment in and around Udgaon village.

2. OBJECTIVES

1. To study wastewater in and around Udgaon village
2. To investigate treatment performance of SHEFROL system for removal of pollutants in wastewater.
3. To compare following parameters of wastewater before and after treatment with disposal standards.
   - i.pH
   - ii. TS (Total solids)
   - iii.TDS(Total dissolved solids)
   - iv.TSS (Total suspended solids)
   - v. DO (Dissolved oxygen
   - vi.BOD(Biochemical oxygen demand)
   - vii. COD (Chemical oxygen demand)
   - viii. Oil and greas
   - ix.N,p,k(Nitrogen, Phosphorus, Potassium)
   - x. Heavy metals -Zinc
4. To make wastewater fit for irrigation purpose.
5. To review the current design approach of SHEFROL system and provide a consolidated approach by using sedimentation tank before SHEFROL system if possible.

3. DESIGN OF SHEFROL

The design of SHEFROL system is done in reference to equalization tank in Gokul dairy in which I have done my industrial training.

Size of equalization tank =9 m X 5 m X 2 m … (For 80000 lit wastewater)

i.e, 90 m3 volume is required for 80000 lit wastewater

I am going to design the SHEFROL system for 500 lit of wastewater.

Therefore, the volume of SHEFROL for 500 lit wastewater is-

$$V = \frac{90 \times 500 \times 10^{-3}}{80000 \times 10^{-3}}$$

$$= \frac{90 \times 500}{80000}$$

$$= \frac{45000}{80000}$$

$$V = 0.5625 \text{ m}^3$$

As V = A X d

Here, depth of root of aquatic plants = 30 cm

= 0.3m

Total depth = root of aquatic plant + extra depth for wastewater flow

= 0.3 m + 0.3 m

d = 0.6 m

$$\text{Now, } A = \frac{V}{d}$$

$$= \frac{0.5625}{0.6} = 0.93 \text{ m}$$

Consider, L = 2 B

L X B = 0.93

2B x B = 0.93

$2B^2 = 0.93$

$B^2 = 0.465$

B = 0.68 m ~1.5 m

L = 2B

= 2 X 0.68

L = 1.36 m ~1.5 m

Total size of SHEFROL = L X B X d

=1.5 m X 1.5 m X 0.6 m

4. CONSTRUCTION OF SHEFROL

Steps-

4.1. Digging of pits

2 pits have digged, one for domestic wastewater and other for industrial wastewater. Size of each pit= 1.5 X 1.5 X 0.6 m. Capacity of each pit=500 liter

4.2 Placing non permeable sheet over pits-

I have placed a polythene sheet over the pit. Size=23 X 23 foot. Density or thickness of polythene sheet= 500GSM (500gm/m^2). I have placed this polythene sheet over the pit to avoid seepage of wastewater into the ground and also to protect groundwater sources from pollution occurs due to seepage of wastewater into it.

4.3. Attaching net to pipe structure

I have used 4 pipes having length 1.4 m and 4 elbows to create structure for one pit, then attached the net to the pipe structure using ties. Material of pipe=PVC. Size of net=1.4 X 1.4 m for each pit. Gap=1 cm

4.4 Attaching foam sheet to pipe structure

Size of foam sheet=1.4 X 1.4 m each for one pit. Thickness of foam sheet=2cm (1 inch)

Density of foam sheet=28 kg/m^3.

4.5 Placing reducers into foam sheet

I have placed the reducers into the foam sheet so that I can put the plants into it. No of reducers = 13 no's for one pit. Size of reducer= 2 x 2.5".Material= PVC

4.6 Passing wastewater through sheets which contains aquatic plants-

I have filled one pit with 500 lit domestic wastewater of udgaon village and another with industrial wastewater.

4.7 Placing aquatic plant over it

I have placed both combined plants in reducers.

4.8 Placing all the structure in pit

I have placed all the structure in respective pit.

5. METHODOLOGY

The study for aquatic plants, selection and collection of species i.e, Cyperus rotundus L and Ipomoea aquatica were done on November, 2018.The design and construction of SHEFROL system is done on October, 2018.

The cultivation of Cyperus rotundus L and Ipomoea aquatic carried out from November 16, 2018 to November 21, 2018 by transferring the wastewater into SHEFROL system.

The actual treatment is started from January 20, 2019 to January 27, 2019 for Post-monsoon season and for pre-monsoon season it is started from May 20, 2019 to May 20, 2019. Collection of samples of both domestic and industrial wastewater is done from January 20, 2019 to January 27, 2019 during post-monsoon season and from May 20, 2019 to May 20, 2019 during pre-monsoon season.

6.CHEMICAL TESTS

pH, TS(Total solids), TDS (Total dissolved solids), TSS (Total suspended solids) , DO (Dissolved oxygen) , BOD (Biochemical oxygen demand) COD(Chemical oxygen demand), Oil and grease N,p,k (Nitrogen, Phosphorus, Potassium), Heavy metals (Zinc). were done at Jaysingpur college, Jaysingpur

7. RESULTS AND DISCUSSIONS

For deteriming the efficiency of each aquatic plant for treatment of wastewater I have firstly conducted experiment in 2lit capacity measuring cylinder.

7.1 Comparison of chemical parameters of domestic wastewater after treatment by cyperus rotundus L, Ipomoea aquatic and combined plants

Sr No	Parameters	Unit	Result				CPCB Std (RANGE)
			Before treatment	After treatment			
				Cyperus rotundus L	Ipomoea aquatic	combined	
1	pH	-	7.51	6.85	7.09	6.63	5.5-9
2	TS	Mg/Lit	926	650	687	605	700
3	TDS	Mg/Lit	886	617	662	585	500
4	TSS	Mg/Lit	40	33	25	20	200
5	DO	Mg/Lit	1.5	0,8	0.8	0.6	0
6	BOD	Mg/Lit	320	208	243	201	30
7	COD	Mg/Lit	400	224	260	187	250
8	Nitrate	Mg/Lit	1.56	1.197	1.23	1.032	1-2
9	Potassium	Mg/Lit	15.39	11.87	12.89	9.11	5-10
10	Phosphorus	Mg/Lit	5.685	3.72	3.92	2.485	0.05-0.5
11	Oil and grease	Mg/Lit	10.2	7.67	8.48	6.137	10

7.2 Comparison of removal efficiencies of chemical parameters of domestic wastewater after treatment by Cyperus rotundus L, Ipomoea aquatica and combined plant

Sr No	Parameters	Unit	Removal efficiency (%)		
			Cyperus rotundus L	Ipomoea aquatic	combined
1	pH	-	8.7	5.59	11.71
2	TS	Mg/Lit	29.8	25.8	34.66
3	TDS	Mg/Lit	30.36	25.28	33.97
4	TSS	Mg/Lit	17.5	37.5	50
5	DO	Mg/Lit	46.66	46.66	60
6	BOD	Mg/Lit	35	24.06	37.18
7	COD	Mg/Lit	44	35	53.25
8	Nitrate	Mg/Lit	23.26	21.15	33.86
9	Potassium	Mg/Lit	22.87	16.24	40.8
10	Phosphorus	Mg/Lit	34.56	31	56.76
11	Oil and grease	Mg/Lit	24.8	16.86	39.83

7.3 Comparison of chemical parameters of industrial wastewater after treatment by Cyperus rotundus L, Ipomoea aquatica and combined plants

Sr No	Parameters	Unit	Result				CPCB Std(Range)
			Before treatment	After treatment			
				Cyperus rotundus L	Ipomoea aquatica	combined	
1	pH	-	4.35	4.78	5.03	6.18	5.5-9
2	TS	Mg/Lit	1250	880	976	796	700
3	TDS	Mg/Lit	1206	844	936	756	500
4	TSS	Mg/Lit	44	36	40	25	200
5	DO	Mg/Lit	0.5	0.3	0.3	0.2	0
6	BOD	Mg/Lit	243	179	181	169	30
7	COD	Mg/Lit	304	224	243	109	250
8	Nitrate	Mg/Lit	1.447	1.116	1.13	1.012	1-2
9	Potassium	Mg/Lit	15.75	11.89	12	9.65	5-10
10	Phosphorus	Mg/Lit	4.03	2.857	3	2.775	0.05-0.5
11	Oil and grease	Mg/Lit	19.144	13.51	14.24	11.37	10
12	Heavy metal-Zinc	Mg/Lit	60	49	53	40	5

7.4 Comparison of removal efficiencies of chemical parameters of industrial wastewater after treatment by Cyperus rotundus L, Ipomoea aquatica and combined plants

Sr No	Parameters	Unit	Removal efficiency (%)		
			Cyperus rotundus L	Ipomoea aquatic	combined
1	pH	-	8.99	13.51	29.61
2	TS	Mg/Lit	29.6	21.92	36.32
3	TDS	Mg/Lit	30.01	22.38	37.31
4	TSS	Mg/Lit	9	9	43
5	DO	Mg/Lit	40	40	60
6	BOD	Mg/Lit	26.33	25.51	30.45
7	COD	Mg/Lit	26.31	20	64.14
8	Nitrate	Mg/Lit	22.87	21.9	30
9	Potassium	Mg/Lit	24.5	23.8	38.73
10	Phosphorus	Mg/Lit	29.1	25.55	31.14
11	Oil and grease	Mg/Lit	29.42	25.61	40.6
12	Heavy metal-Zinc	Mg/Lit	38.33	25	66.3

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7.5 Concentration of Chemical parameter of Domestic wastewater before and after treatment by combined plant at post-monsoon season

Day	Test performed									
	pH	TS	TDS	TSS	DO	BOD	COD	Nitrate	Potassium	Phosphorus	Oil and grease
1	7.51	926	886	40	1.5	320	400	1.56	15.39	5.685	10.2
2	7.5	924	885	39	1.5	318	397	1.5	15.11	5.65	10.18
3	7.3	895	857	38	1.3	301	355	1.449	14.59	4.88	9.15
4	7.11	815	783	32	1.1	288	304	1.315	12.24	4.44	8.86
5	6.97	730	701	29	0.9	257	281	1.29	11.87	3.6	8.15
6	6.81	690	663	27	0.8	215	233	1.25	10.15	3	7.85
7	6.68	644	592	22	0.6	209	200	1.055	9.3	2.5	6.2
8	6.63	605	585	20	0.6	201	187	1.032	9.11	2.485	6.137

7.6 Concentration of Chemical parameter of Industrial wastewater before and after treatment by combined plant at Post-monsoon season

Day	Test performed										
	pH	TS	TDS	TSS	DO	BOD	COD	Nitrate	Potassium	Phosphorus	Oil and grease	Heavy metal-zinc
1	4.35	1250	1206	44	0.5	243	304	1.447	15.75	4.03	19.144	60
2	4.39	1246	1203	43	0.5	240	300	1.42	15	4	19.1	60
3	5.1	1200	1160	40	0.4	228	280	1.35	14.85	3.65	18.55	57
4	5.41	1101	1063	38	0.4	215	240	1.3	12.01	3.22	17.46	51
5	5.59	957	924	33	0.3	195	170	1.27	11.45	3.01	15.85	46
6	5.89	833	803	30	0.3	180	120	1.21	10.33	2.99	13.5	43
7	6.11	810	763	27	0.2	170	110	1	9.75	2.8	11.5	42
8	6.18	796	756	25	0.2	169	109	1.012	9.65	2.775	11.37	40

7.7 Concentration of Chemical parameter of domestic wastewater before and after treatment by combined plant at Pre-monsoon season

Day	Test performed										
	pH	TS	TDS	TSS	DO	BOD	COD	Nitrate	Potassium	Phosphorus	Oil and grease
1	7.68	969	939	32	1.6	327	406	1.67	16.2	5.77	12.6
2	7.5	960	930	30	1.5	315	400	1.6	16	5.22	12.4
3	7.15	851	823	28	1.4	300	375	1.51	15.11	4.86	11.47
4	7.05	800	774	26	1.2	296	350	1.45	14.55	4.33	10.57
5	6.93	732	707	25	1	267	315	1.33	13.9	3.91	9.45
6	6.85	699	675	24	0.8	250	236	1.23	12.77	3.44	8.59
7	6.8	650	628	22	0.7	220	200	1.1	10	3	8
8	6.78	637	617	20	0.6	202	182	1.07	9.85	2.27	7.6

8. RESULT

8.1 Comparison of chemical parameters of domestic wastewater after treatment by combined plants between Pre-monsoon and post-monsoon season

Sr No	Parameters	Unit	Result		CPCB Std (Range)
			Post-monsoon season	Pre-monsoon season	
1	pH	-	6.63	6.78	5.5-9
2	TS	Mg/Lit	605	637	700
3	TDS	Mg/Lit	585	617	500
4	TSS	Mg/Lit	20	20	200
5	DO	Mg/Lit	0.6	0.6	0
6	BOD	Mg/Lit	201	202	30
7	COD	Mg/Lit	187	182	250
8	Nitrate	Mg/Lit	1.032	1.07	1-2
9	Potassium	Mg/Lit	9.11	9.85	5-10
10	Phosphorus	Mg/Lit	2.485	2.27	0.05-0.5
11	Oil and grease	Mg/Lit	6.137	7.6	10

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8.2 Comparison of removal efficiencies of chemical parameters of domestic wastewater after treatment by combined plants Between Pre-monsoon and post- monsoon season

Sr No	Parameters	Unit	Removal efficiency (%)	
			Post-monsoon season	Pre-monsoon season
1	pH	-	11.71	11.71
2	TS	Mg/Lit	34.66	34.26
3	TDS	Mg/Lit	33.97	34.29
4	TSS	Mg/Lit	50	37.5
5	DO	Mg/Lit	60	62.5
6	BOD	Mg/Lit	37.18	38.22
7	COD	Mg/Lit	53.25	55.17
8	Nitrate	Mg/Lit	33.86	35.92
9	Potassium	Mg/Lit	40.8	39.19
10	Phosphorus	Mg/Lit	56.76	60.65
11	Oil and grease	Mg/Lit	39.83	39.68

8.3 Comparison of chemical parameters of industrial wastewater sample after treatment by combined plants at post-monsoon season

Sr No	Parameters	Unit	Result	CPCB Std
			Post-monsoon season	
1	pH	-	6.18	5.5-9
2	TS	Mg/Lit	796	700
3	TDS	Mg/Lit	756	500
4	TSS	Mg/Lit	25	200
5	DO	Mg/Lit	0.2	0
6	BOD	Mg/Lit	169	30
7	COD	Mg/Lit	109	250
8	Nitrate	Mg/Lit	1.012	1-2
9	Potassium	Mg/Lit	9.65	5-10
10	Phosphorus	Mg/Lit	2.775	0.05-0.5
11	Oil and grease	Mg/Lit	11.37	10
12	Heavy metal-Zinc	Mg/Lit	40	5

8.4 Comparison of removal efficiencies of chemical parameters of Industrial wastewater after treatment by combined plants at post-monsoon season

Sr No	Parameters	Unit	Removal efficiency (%)
			Post-monsoon season
1	pH	-	29.611
2	TS	Mg/Lit	34.66
3	TDS	Mg/Lit	33.97
4	TSS	Mg/Lit	50
5	DO	Mg/Lit	60
6	BOD	Mg/Lit	37.18
7	COD	Mg/Lit	53.25
8	Nitrate	Mg/Lit	33.86
9	Potassium	Mg/Lit	40.8
10	Phosphorus	Mg/Lit	56.76
11	Oil and grease	Mg/Lit	39.83
12	Heavy metal-Zinc	Mg/Lit	33.33

9.CONCLUSION

From overall study, it can be concluded that the treatment if domestic and industrial wastewater by using SHEFROL system is fair satisfactory but it can be more satisfactory by providing some preliminary process.

1.By studying measuring cylinder experiment which is conducted on each plant, it is seen that the treatment / removal efficiency of contaminants from both wastewater is more in combined plants (11.71-60 %) than individual plants i.e, for cyperus rotundus L 8.7-46.66%) and for Ipomoea aquatic(5.59-46.66%) for domestic wastewater and for industrial wastewater it is(29.6-60%) for combined plants and (8.99-40%) for cyperus rotundus L and (1.51-40%) for Ipomoea aquatica plant.

2. From above values. it is seen that the treatment efficiency of combined plants is more. Therefore, I have performed SHEFROL system using both plants in combined manner.

3. For Domestic wastewater, It is seen that the removal efficiency of pH is 11.71% in both pre and post-monsoon season and for TS, TDS, TSS, DO, BOD, COD, nitrate, potassium, phosphorus, oil and grease are 34.66 %, 33.97%, 50%, 60%, 37.18%, 53.25%, 33.86%, 40.8%, 56.76%, 39.83% respectively during post-monsoon season and during pre-monsoon season it is 34.26%, 34.29%, 37.5%, 62.5%, 38.22%, 55.17%, 35.92%, 39.19%, 60.65%, 39.68% respectively.

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4.For industrial wastewater, it is seen that the removal efficiency of pH, TS, TDS, TSS, DO, BOD, COD, nitrate, potassium, phosphorus, oil and grease and Heavy metal-Zinc are 29.61%, 34.66%, 33.97%, 50%, 60%, 37.18%, 53.25%, 33.86%, 40.8%, 56.76%, 39.83% , 33.33% respectively during post-monsoon season.
5.For Domestic wastewater, The values of pH, TS, TSS, COD, nitrate, potassium, oil and grease are within permissible limit .and the values of TDS, DO, BOD, phosphorus are not in the permissible limit after treatment during both pre-monsoon and post-monsoon season.
6.For industrial wastewater, The values of pH, TSS, COD, nitrate, potassium are within permissible limit .and the values of TS, TDS, DO, BOD, phosphorus, oil and grease and Heavy metal-Zinc are not in the permissible limit after treatment during post-monsoon season.

SUGGESTIONS-

1. Increase quantity of aquatic plants by providing extra number of reducers. By increasing quantity of aquatic plants treatment efficiency can be increased.
2. For increasing removal efficiency of TS, TSS, TDS provide sedimentation tank before SHEFROL system as primary treatment.
3. In industrial wastewater, due to acidic pH, aquatic plants were not alive which resulted in decrease in treatment efficiency. To solve this problem, we can cultivate other plants which can tolerate acidic pH.
4. By treating wastewater using aquatic plants which can tolerate acidic pH, we can increase pH value which is suitable for treatment by the aquatic plants which were used in SHEFROL system.
5. Add chemicals into the industrial wastewater for pH neutralization so that aquatic plants can perform treatment process effectively.

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