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Use of solar powered aerator for improving performance of conventional Sewerage Treatment Plant based on waste stabilization pond technique

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In treatment of waste water (domestic sewage) waster stabilization pond is very old and conventional technology. This technology is based on primary and secondary treatment using natural process of anaerobic and aerobic nature which helps to reduce organic load of waste water and helps in overall cleaning of waste water using minimum external resources. Traditionally a sewerage treatment plant based on waste stabilization pond technique consist anaerobic tank with approx one day retention time, facultative pond with approx 10 days retention time and maturation pond with 10 days retention time. Conventionally the total achievement of results in waster stabilization pond in terms of production of BOD are 90 to 95% with the help of this system BOD near to 30mg / L are achieved but for further reduction of BOD beyond 30 mg/L tertiary treatment is required which consumes a lot of land. So in this study, the aeration of waste water is improved with the help of paddler type aerator powered with the help of solar power. The results are analyzed in departmental laboratory for various parameters like pH, TSS, BOD, COD and fecal coliform for evaluation of performance of aerator. A correlation in the quantity of sewerage treated with amount of oxygen supplied is tried to establish so optimum number of aerators for desired level of results can be established along with benefits of using solar technology for aeration depicting invest cost with electrical expenditure of normal aerator is tried to find for the purpose of finding financial sustainability of the research.

Keywords

Waster stabilization pond, solar power, floating paddle aerator,

Introduction

In Malot town, Punjab a 3 MLD STP based on waste stabilization pond is present which consist of three step process including Anaerobic Pond, Facultative Pond and maturation Pond which has total retention time of 15 days. (Anaerobic Pond 1 Day HRT, Facultative Pond 12 days HRT and Maturation Pond 2 Days HRT). It is normally observed that for anaerobic pond with one day HRT Reduction in BOD under normal process is approx 58% which is accompanied with further reduction in Facultative ponds about 10% and further due to very less HRT of normally two days in the maturation pond normal decay is 5-8% only also it is observed due to insufficient sizes of maturation pond the reduction in organic bacteria and pathogens is also less due to which outlet water is having sufficient quantity of fecal coliform. So in order to improve functional operation of maturation ponds, this is not possible in natural way with low retention time of maturation ponds. Artificial oxygenation with the help of solar based aerator is introduced to study effect of aeration in existing maturation ponds for improvements in result of waste water. Also the concept of solar based aerator is introduced considering the fact not to increase the operation and maintenance cost of existing WSP based STP in order to avoid additional burden of reoccurring expenditure on ULB.

Research Objective

To design a prototype of solar aerator and study its application in maturation pond improvement and find out the optimum usage of solar aerator in meeting oxygen demand.

Concept Design

For the purpose of aeration paddler type aerator is very common and readily available everywhere. Also the mixing efficiency of paddler type aerator is also high in comparison to other type of aerators available. During this study from various previous researches done in aerator application limitation of paddler type aerator are studied and their solution is incorporated while finalizing design of this new paddler type aerator. In previous study common problem with paddler aerator are mainly like use of DC motor for rotating paddles, low initial torque in DC motor, Frequent burning of motor due to direct current fluctuations due to weathering and clouds are common issues. Which are the key concern to design a more sustainable and robust design of aerator which can with stand all above mentioned issues also in addition to above planning is done in such a way to minimize the maintenance cost of aerator.

So in order to see all previous researches it is recommended to use a 2Hp induction Motor which delivers high initial torque in comparison of a DC motor. For using a induction motor with solar power a variable frequency drive to convert DC power to AC power is introduced as per the power requirement of motor. Also to encounter fluctuations due clouds and weathering effect variable frequency drive will help in providing uniform power to induction Motor so motor can be made operational at low RPM in case of less sun light due to clouds and life of motor can be maximized. The concept design is as follows:-

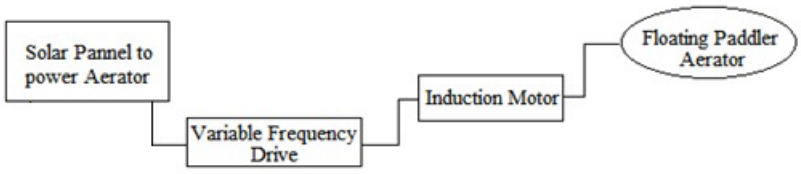

Fig 1- shows typical arrangement of various part of aerator

Design of aerator and field setup

The prototype of solar power based aerator is made with considering low cost available components in market especially for the purpose of reproduction of this prototype at a low cost and can be implemented in various STPs across the country. Various Components considered in the development of prototype are listed as follows:-

Specification of Setup Required for Prototype			
1. Float Specifications		**4. Aerator Specifications**	
Type of Aerator	Surface Floating	No. of Paddle	4
Material of Construction	HDPE for waste water application	Oxygenate Capability	2.5-2.8 kgO2/hrs
Number of floats	5 Nos	Maximum paddling speed	120-150 RPM
Total weight of assambly	105 kg	Flow Range	27-30 m
2. Variable Frequency Drive		**5. Induction Motor Specifications**	
Power	2.2 Kw	Voltage	220V +/- 10V (AC)
Input	AC 1PH 200-240V 24A & DC 250-350V 18A	Motor Phase	2 hp - 3 phase
Output	AC 3PH 0-Uinput V 9.5A 0-600 Hz	Motor	1.5 kw
3. Solar Panels		Power Source	AC , Variable frequency drive
Number of panels	6	Maximum RPM	1440
Power	335 WATTS		
Size of Panel	1m width and 2 meter Length		

Table 1 – Showing specification of various components required for Aerator assembly

The typical layout for the assembly of above mentioned components in maturation pond is shown as following details:

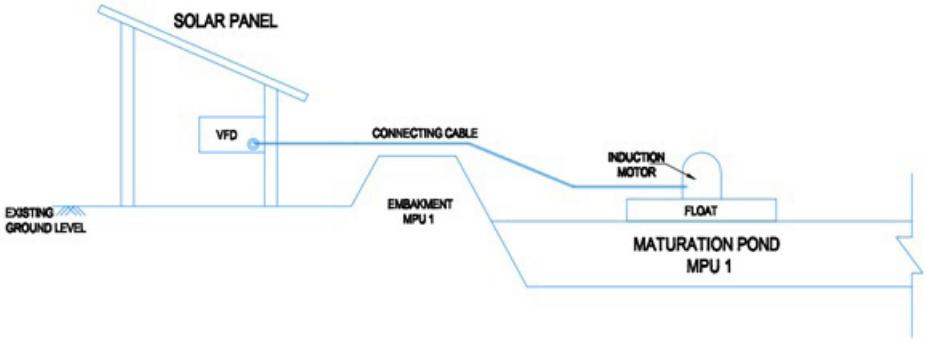

Fig 2- shows field setup of various part of aerator at WSP based STP, Malot

Data collection and analysis of results

The following plan shows systematic layout of various components of 3MLD Sewerage treatment plant based on waste stabilization technology also showing the location of aerator in maturation pond and flow pattern of sewerage treatment plant. Also the points of sampling for analyzing various parameters of waste water are shown to establish various relations between STP components and effect of adding aeration with the help of prototype used in this research. The details and plan/aerial view of STP is as follows:-

Fig 3- aerial view of WSP based STP, Malot showing components & sampling locations

As per the research point of view five sampling locations listed below are selected, the samples for waste water parameters like pH, TSS, BOD, COD & faecal coliform were selected & results are analyzed before implementation of prototype as well as improvement after installation of prototype.

Sr No	Sampling point	Location
1	SP1	At inlet of Anerobic Pond
2	SP2	At inlet of Faculative Pond
3	SP3	At inlet of Maturation Pond 1
4	SP4	At outlet of Maturation pond 1
5	SP5	At outlet of Maturation Pond 2nd final

Table 2 – List of sampling points selected for sample collection

The results of waste water samples from above mentioned points are collected to see step wise reduction/ improvement in characteristics of waste water sample before installation of prototype and after installation on various days are observed to analyze the results and reach on conclusive outcome.

Results of waste water at differnat locations of STP before and after instaling prototype									
S No	Date of sampling	sampling before or after protype	Sampling Point	Smaple Location	Parameters of waste water				
					pH	TSS(mg/l)	COD(mg/l)	BOD(mg/l)	Fecal Coli
1	30.06.2020	BEFORE	SP5	Final Outlet	7.7	97	162	68	5000
2	09.07.2020	BEFORE	SP1	Inlet Anerobic pond	6.5	122	355	120	36000
			SP2	Inlet Facultative pond	7	94	217	75	-
			SP3	Inlet of Maturation Pond 1	7	50	150	68	-
			SP4	Inlet of Maturation Pond 2	7	48	145	59	-
			SP5	Outlet of Maturation Pond 2	7	42	140	53	5500
3	13.07.2020	AFTER	SP1	Inlet Anerobic pond	7.8	127	282	113	35000
			SP2	Inlet Facultative pond	7.7	96	224	80	-
			SP3	Inlet of Maturation Pond 1	7.7	73	146	67	-
			SP4	Inlet of Maturation Pond 2	7.7	64	120	50	-
			SP5	Outlet of Maturation Pond 2	7.7	44	98	41	2000
4	16.07.2020	AFTER	SP1	Inlet Anerobic pond	7.5	97	186	89	33000
			SP2	Inlet Facultative pond	7.5	73	148	68	-
			SP3	Inlet of Maturation Pond 1	7.5	69	145	61	-
			SP4	Inlet of Maturation Pond 2	7.4	67	138	48	-
			SP5	Outlet of Maturation Pond 2	7	50	96	43	2100

Table3- Results of sample collected for analysis of performance of prototype

Conclusions

1. The study and results at various locations of STP shows a sufficient improvement of results after installation of prototype as aeration done with the help of prototype increases oxygen level in maturation pond and improves aerobic process in maturation ponds which helps aerobic bacteria to fasten the process of treatment.
2. The study shows with installation of prototype in maturation pond 1 performance in BOD reduction maturation pond increases to additional 10% then its own natural BOD reduction potential.
3. The study also depicts with increase in oxygen level in maturation pond also results reduction of feacal coliform in final outlet due to decay of organic matter by additional aeration then normal process.
4. To improve results of maturation pond to further extent more number of aerators are required to meet oxygen demand.

Suggestions

1. The prototype shows considerable improvement of reduction of waste water parameters in maturation pond with supplying additional aeration and is economical as no power is required to operate the prototype in comparison to conventional aeration.

2. As the operation of prototype is automatic with sun movement no operator is required to switch ON/OFF the prototype which makes it more beneficial for remote STPs where staffing is an issue.
3. Further the cost compression of prototype also helps in calculating additional cost then conventional aerator which is covered in 9-10 Months operational cost of conventional aerator.
4. The prototype is having sufficient scope for future research to improve functionality of waste stabilization based STPs to further improvements of results.

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