Advanced Aeration INC.

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United States Air Force and the Texas Research Institute for Environmental Studies (TRIES) - Evaluation of Vacuum Bubble® Technology (VBT™) - A Case Study

Introduction

Vacuum Bubble® Technology (VBT™) creates micro bubbles of air that are neutrally buoyant. The bubbles are created under a partial vacuum and, as a result, the internal pressure of the bubbles is lower than that of the surrounding water. Consequently, the bubbles collapse to an average dimension of 0.25 mm in diameter. Because of their small size and neutral buoyancy, the bubbles remain in the water for many minutes. These micro bubbles increase the oxygen transfer potential in the water which, in turn, enables aerobic bacteria to consume the organic waste in the water.

Background

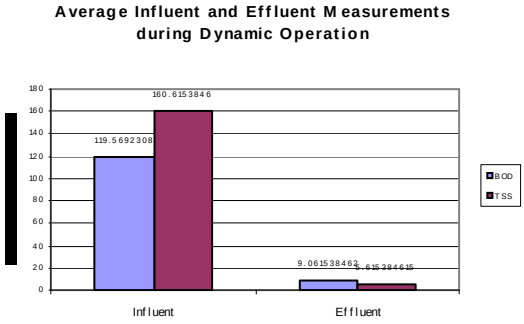
The United States Military finds itself deploying its forces to distant and remote parts of the world and into locations where there is no infrastructure to support normal daily activities. The Military refers to these locations as “bare bases”. For health reasons, and from environmental considerations, the Military has set out to develop biological treatment systems capable of treating a variety of waste (Municipal, Industrial, and Biological) for its deployments. Over a period of two years, the Texas Research Institute for Environmental Studies (TRIES), working with the US Air Force’s Air Force Institute for Operational Health (AFIOH) has conducted feasibility and engineering studies to develop these portable units. There have been many issues and problems to overcome in this development process, but throughout, the inclusion of VBT™ in the configurations to treat the organic waste has been the one consistently successful and trouble free component.

Phase I

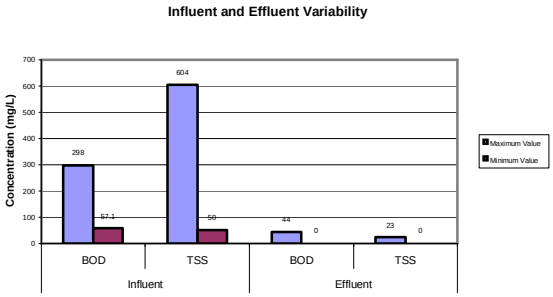
The purpose of Phase I was to investigate a viable and economic treatment process for municipal wastewater streams. Dynamic tests were conducted over a three and a half month period and these pilot, scale tests included a VBT^{TM} unit in combination with bioaugmentation using a consortium of various microorganisms. Biological retention times ranging between 3.18 hours and 9.56 hours were evaluated to determine the optimal biological retention time required to effectively produce BOD_5 and TSS effluent levels of less than 20 mg/L.

Results

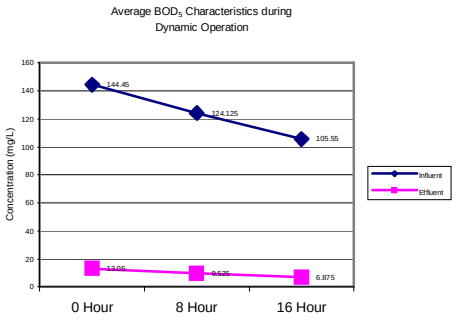
The proof of concept bioreactor met and exceeded the BOD_5 and TSS goals of less than 20 mg/L for Phase I research. The proof of concept system was found to be capable of treating municipal wastewater in a dynamic fashion with an overall retention time less than 11 hours with a treatment capacity ranging from 2,880 to 3,600 gallons per day. Future objectives developed from Phase I led to the construction of a prototype unit capable of treating a minimum of 7,700 gallons of municipal wastewater per day.



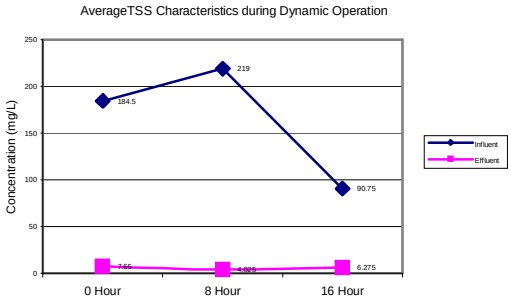
Average influent and effluent values for 5 tests that met the project objectives of effluent discharge with 20 mg/L BOD and TSS.



Average influent and effluent values for 5 tests that met values of BOD and TSS for the influent and effluent throughout operation.

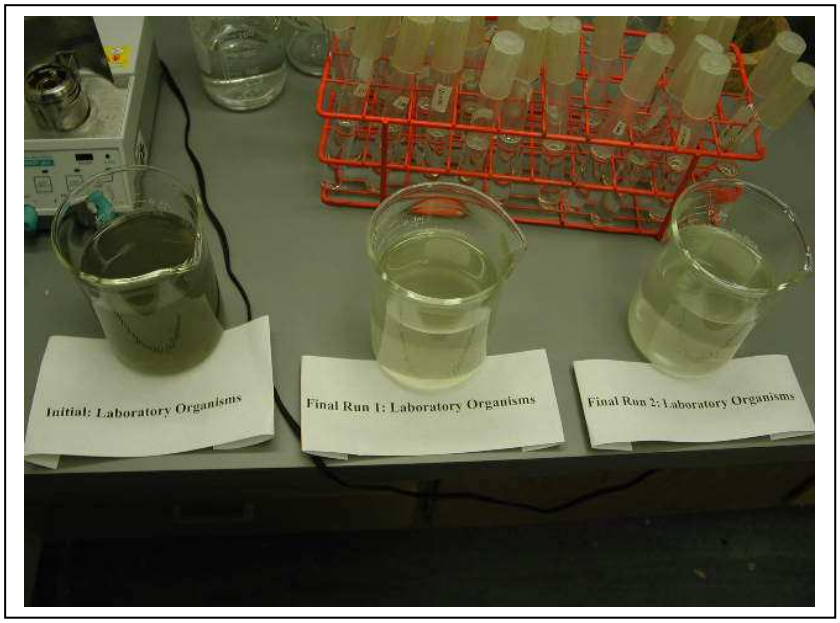


Time course measurements of the average influent and effluent BOD readings following conversion of the system to dynamic operation.



Time course measurements of the average influent and effluent TSS readings following conversion of the system to dynamic operation.

VBT™ Cleans the Water



Phase II

Phase II of the US Air Force/TRIES project was the development of a fully operational, portable bioreactor system. The outcome was the Deployable Aerobic Aqueous Bioreactor[1] - The "DAAB"

Features

The DAAB is a new bioreactor system designed to treat industrial and municipal wastewaters which, at the same time, is easy to deploy and operate. When in operation, it produces only small amounts of sludge and little or no discernible odor. The system can be fully functional and meeting EPA release requirements in less than 24 hours. The bioreactor has a small, flexible foot print that can be set up as a self contained, stand alone unit, or incorporated into other wastewater treatment systems occupying as little as 400 sq ft space. It is a low energy system using less than10 kW/h daily. Other uses for the DAAB include sanitation and environmental cleanup for communities affected by natural disasters.

Operation

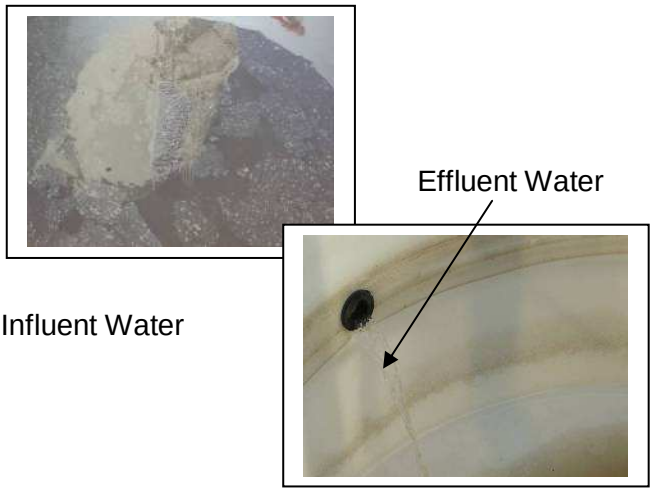
Incorporated into the system is a VBT™ aerator that provides an oxygen saturated environment to maximize the aerobic metabolism of the microorganisms. The system uses bio-augmentation to optimize the growth of healthy biofilms, and the system's design optimizes the metabolism of selected wild type microorganisms by increasing their collisions with biodegradable waste products. Finally, the DAAB system[1] utilizes gravity to reduce operational costs.

[1] Patent Pending

Results of Sanitary Wastewater Tests

	Influent Wastewater	Treated Effluent
BOD_5	152.2 mg/L	23.0 mg/L
TSS	269.0 mg/L	15.9 mg/L
pH	8.3	7.9
Temp	21.7º C	21.5º C

Average values after 8 hours of hydraulic retention



Influent Water | Effluent Water

Industrial Wastewater

The DAAB system[2] has undergone extensive testing to establish its ability to degrade numerous VOCs from industrial wastewater, within 24 hours of exposure. The ability of the microorganisms to degrade VOCs is enhanced when provided with the micro bubbles produced by the VBT™ in the DAAB environment. Microorganisms in the DAAB environment were found to be resistant to VOC concentrations in excess of 80 ppm.

[2] Patent Pending

VOCs found in industrial wastewater and the impact of DAAB on their concentrations

Volatile Organic Compounds	MDL	Reporting Limit	Influent Average	Effluent Average
1,2,4-Trimethylbenzene	0.28	0.94	18.74	< 0.94
1,3,5-Trimethylbenzene	0.26	0.90	3.16	< 0.90
2-Chlorotoluene	0.28	0.95	1.184	< 0.95
Chloroethane	0.29	1.00	2.65	< 1.00
Chloroform	0.19	0.64	1.76	1.176
cis-1,-2-Dichloroethene	0.21	0.71	1.478	< 0.71
m,p-Xylene	0.22	0.75	0.8925	< 0.75
Methylene chloride	1.98	5.00	193.264	19.862
Naphthalene	0.24	0.81	135.848	1.026
n-Butylbenzene	0.41	1.39	24.102	1.6
n-Propylbenzene	0.28	0.96	1.135	< 0.96
o-Xylene	0.19	0.66	1.318	< 0.66
p-Isopropyltoluene	0.35	1.21	2.352	< 1.21
sec-Butylbenzene	0.36	1.23	1.484	< 1.23
Toluene	0.21	0.71	1.116	< 0.71

Results of Industrial Wastewater Tests

	Influent Wastewater	Treated Effluent
BOD_5	92.2 mg/L	42.2 mg/L
TSS	16.0 mg/L	10.6mg/L
pH	7.9	7.4
Temp	24.7º C	25.0º C

Average values after 10 hours of hydraulic retention

Benefits of DAAB

- The system produces little or no odor.
- Only about 1% sludge is generated.
- It produces effluent acceptable to EPA standards within 24 hours following setup.
- A fixed film reactor capable of complete digestion is utilized.
- The DAAB operates on approximately 1/5 power required to operate units with comparable treatment capacities.
- The DAAB is less expensive than comparable technologies based upon utilization, power consumption, and capacity

Comparison of DAAB with Similar Wastewater Technology

	Transport			People	Wt #	Daily Power		Capacity	Set-Up	Cost of Unit
	Hwy	Marine	Air			kW	$PG	GPD	Time in Days	
DAAB System	**Yes**	**Yes**	**Yes**	**550 1000**	**9,000**	**29.58 29.58**	**0.003 0.001**	**10,000 25,000**	**0.5**	**$200,000**
EEC Global	Yes	Yes	?	600	41,800	261.0	0.008	31,000	4*	$273,000
Hydroxil	Yes	Yes	?	500 – 1000	50,000	226.2	0.009	25,000	4-5*	$250,000
Seapoint	Yes	Yes	No	500 – 1000	27,000	208.8	0.01	20,000	2*	
Smith Loveless	Yes	Yes	No	500 – 1000	120,000	278.4	0.014	20,000	5*	$190,000
Orenco	Yes	Yes	No	1	4,000	20.88	0.017	1,200	**	$7,800

* = Requires Engineering Company
** = Requires burial and construction work