THE PERFORMANCE OF A DEEP PRIMARY WASTE STABILIZATION POND

BY

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This Thesis is

Respectfully Dedicated to

THE PARENTS

of the author.

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ABSTRACT

This thesis describes an investigation into the performance of a deep primary waste stabilization pond under warm climatic conditions. Wastewater treatement designers in developing countries are constantly faced with the problem of selecting a system that is both efficient and economic. The main objective of this study was to determine safe loading rate and retention time in a pond deeper than the ponds normally used in warm climates. A secondary objective was to study the effect of using a deep pond in conjunction with a secondary shallow pond.

A pilot-scale pond of 3.6m depth as primary pond and an oil drum of 199 l capacity as secondary shallow pond were used under field conditions for the experimental study. The performance was evaluated by measuring influent and effluent BOD, COD and TC along with the measurements of DO, temperature, and pH profiles. Experimental results have shown that the high loaded deep pond is effective in the removal of bacteria and organic matter. A linear regression equation has been obtained for BOD and COD of raw domestic wastewater in order to predict BOD from COD measurements. The straight line regression equations have also been obtained to predict BOD and COD areal removal rates, covering ranges of 575 to 1406kg BOD/ha.d and 1137 to 2912kg COD/ha.d.

Average climatological factors from records of a 25 year period were analysed and the permissible areal organic loading computed. From this analysis and the experimental results obtained, it was concluded that the maximum areal loading should be limited to 640kg BOD/ha.d(or about 1300kg COD/ha.d) with a minimum hydraulic retention time of 11 days. Experimental study also revealed that the combination of a deep pond followed by a secondary pond can produce a high quality effluent in terms of soluble organics and bacterial numbers. An empirical equation to

predict BOD removal efficiency when volumetric organic loading is known was developed by analysing the experimental results and data collected from several publications. Using this equation, a chart to select suitable pond depths for different loading rates has also been developed.

Beneficial and adverse effects of tropical climates on pond performance are identified and discussed. The areas which require further study and development are also identified and recommendations made for future investigations.

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LIST OF SYMBOLS

A	Surface area
Ac	Acre
BOD	This refers to 5 day Biochemical Oxygen Demand at 20° C. For simplicity this is used throughout the report instead of BOD_5^{20}
BOD_u	Ultimate Biochemical Oxygen Demand
C	Concentration of tracer at any time
C_o	Initial concentration of tracer
C_s , C_c	Concentration of algae
COD	Chemical Oxygen Demand
COD_T	Total Chemical Oxygen Demand
D	Coefficient of dispersion, time in days
DO	Dissolved Oxygen
d_o	Depth
d	Depth, time in days
°C	Degree Celcius
°F	Degree Fahrenheit
E	Removal efficiency in percentage
E_s	Fraction of solar energy fixed in organic matter
ESBOD	Effluent Soluble Biochemical Oxygen Demand
ESCOD	Effluent Soluble Chemical Oxygen Demand
F	Efficiency of energy conversion
FC	Faecal Coliforms
FS	Faecal Streptococci
f	Maximum fraction of light utilized
H	Stored energy
h	Calorific value of algae, time in hours
ha	Hectare
Id	Light intensity at depth d.
Ii	Incident light intensity
I_s	Saturation light intensity
ITBOD	Influent Total BiochemicalOxygen Demand.
ITCOD	Influent Total Chemical Oxygen Demand
k	Reaction rate constant for BOD
k_b	Reaction rate constant for Bacteria
k_s	Reaction rate constant for sludge
k_g	Kilogram

L	Length of travel path, organic loading
L_f	Load factor
L_v	Volumetric organic loading rate
L_t	BOD at any time t
L_o	Areal loading rate
L_r	Areal removal rate
l	Litre
lb	Pound
MJ	Mega Joules
M_T	Mass of tracer instantaneously dropped into the reactor.
m	Metre
mm	Millimetre
mg	Milligram
ml	Millilitre
mv	Millivolt
N	Number of organisms remaining
N_o	Number of organisms originally present
ORP	Oxidation Reduction Potential
OL	Organic Loading
P	Mass of oxygen produced per unit mass of algae
Q	Rate of flow
Q_i	Inflow rate
Q_o	Outflow rate
Re	Reynolds number
r	Sky clearance factor
S	Solar radiation, concentration of pollutant
S_o	Influent concentration of pollutant
S_{av}	Average Solar radiation
S_{min}	Minimum solar radiation
S_{max}	Maximum solar radiation
SP	Secondary Pond
SS	Suspended Solids
T	Temperature, ambient mean monthly temperature
T_c	Temperature coefficient
T_o	Initial temperance
T_t	Surface temperature
T_s	Sludge temperature
TC	Total Coliforms

TOC	Total Organic Carbon
t	Retention time
$\bar{t}$	Theoretical retention time
U	Mean velocity
V	Volume, velocity
W	Width, Watts
Z	Depth
α	Specific light absorption coefficient
δ	Dispersion number
F(θ)	Fraction of material at the outlet as a function of dimensionless θ (ie time)
μg	Microgram
ν	Kinematic viscosity
θ	Temperature coefficient, retention time
θ_c	Mean retention time
θ_{pf}	Plug flow deviation
λ	Species constant
λ_0, λ_i	Areal organic loading rate
λ_r	Areal organic removal rate