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Evaluation of the overall performance and relationship with operational variables at 73 full-scale primary facultative ponds

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Waste stabilization ponds - WSP

- Effective alternatives for treating wastewater, and constitute the simplest form of wastewater treatment

- Actual performance of full-scale WSP is not covered in the literature in detail, especially in systems operating in tropical developing countries

Waste stabilization ponds - WSP

- There are very few consolidated reports on the existing performance, based on an evaluation of operating records of the ponds

Main objective

- To compare the observed effluent concentrations of the ponds and the typical values reported by the technical literature

- Variations in the BOD effluent quality from facultative ponds were also investigated by means of the multivariate analysis

Introduction

- Principal component analysis (PCA) was applied to evaluate the influence of some operational parameters and physical characteristics on the performance of the ponds

- PCA is multivariate statistical technique used to identify important components that explain most of the variances of a system, reducing the number of variables to a small number of indices

Methods

Data analysed =

- obtained directly from the operational records of the Water and Sanitation companies

- 73 full-scale primary facultative ponds located in Southeast Brazil, in the states of São Paulo and Minas Gerais

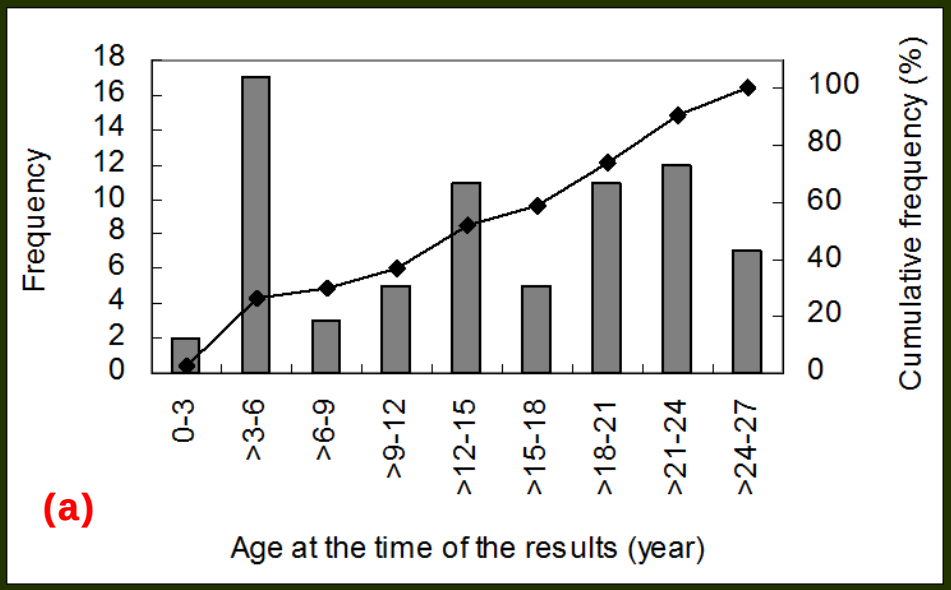
Methods

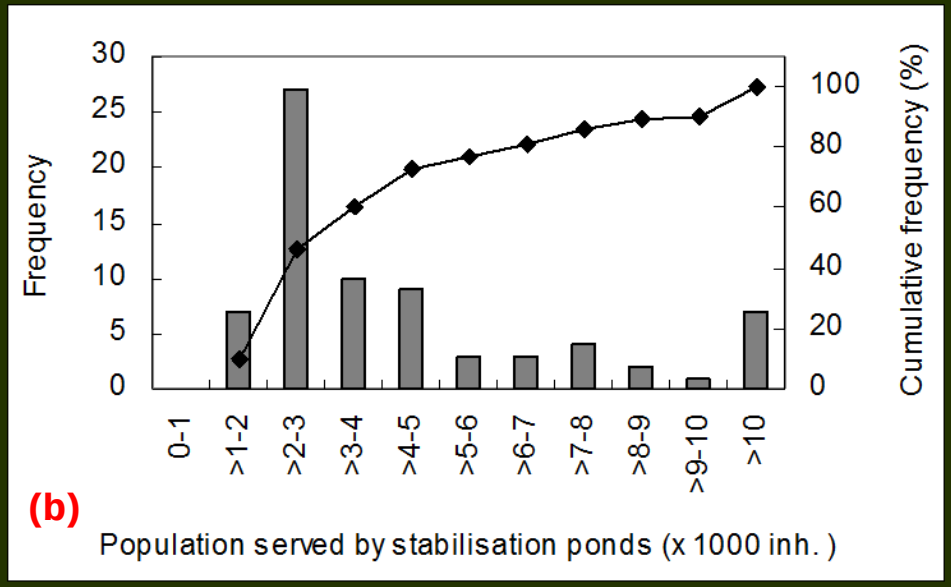
Parameters analysed by means of the multivariate analysis to discriminate sources of variation of **BOD effluent quality** from the facultative ponds

Parameters	Abbreviations	Units
Flow	FLOW	m^3d^{-1}
Effluent biochemical oxygen demand	EFFLBOD	mgL^{-1}
BOD removal efficiency	EFFICBOD	%
Surface BOD loading	Ls	$kgBOD.ha^{-1}.d^{-1}$
Hydraulic retention time	HRT	days
Geometry (length/breadth ratio)	L/B	
Temperature of the liquid	TLIQ	^oC
Area	A	Há
Depth	DEP	m
Population served by the ponds	POP	Inhabitants
Age of the pond at the time of the results	AGE	years

Results and discussion

Age of the ponds (a) and population served by facultative ponds (b)





- The average size remains close to 4200 inhabitants and the average age is over 15 years old

Results and discussion

Typical values expected and the ranges effectively observed for the ponds in operation, considering the 10% and 90% percentiles

Constituent	Ranges	Concentration (mgL^{-1})	Removal efficiencies (%)
BOD	Literature [1]	50 to 80	75 to 85
	Actual	88 to 176	65 to 84
COD	Literature	120 to 200	65 to 80
	Actual	348 to 677	42 to 71
TSS	Literature	60 to 90	70 to 80
	Actual	127 to 344	70 to 83
TN	Literature	> 20	< 60
	Actual	51 to 83	27 to 48
TP	Literature	> 4	< 35
	Actual	3 to 7	32 to 59
FC	Literature	10^6 to 10^7	1.0 to 2.0
	Actual	$2x10^5$ to $2x10^6$	1.1 to 2.4

[1] Adapted from Mara (2003), Metcalf & Eddy (2003), von Sperling & Chernicharo (2005)

Results and discussion

- A great difference was noticed between the ranges reported by the literature and those effectively observed, taking into consideration all the constituents

- In general, the performance of the FAC1ary was lower than expected, considering removal efficiencies and effluent concentrations

Results and discussion

In view of the large performance diversity observed, PCA was used for a simultaneous interpretation of the factors that could affect the effluent variability

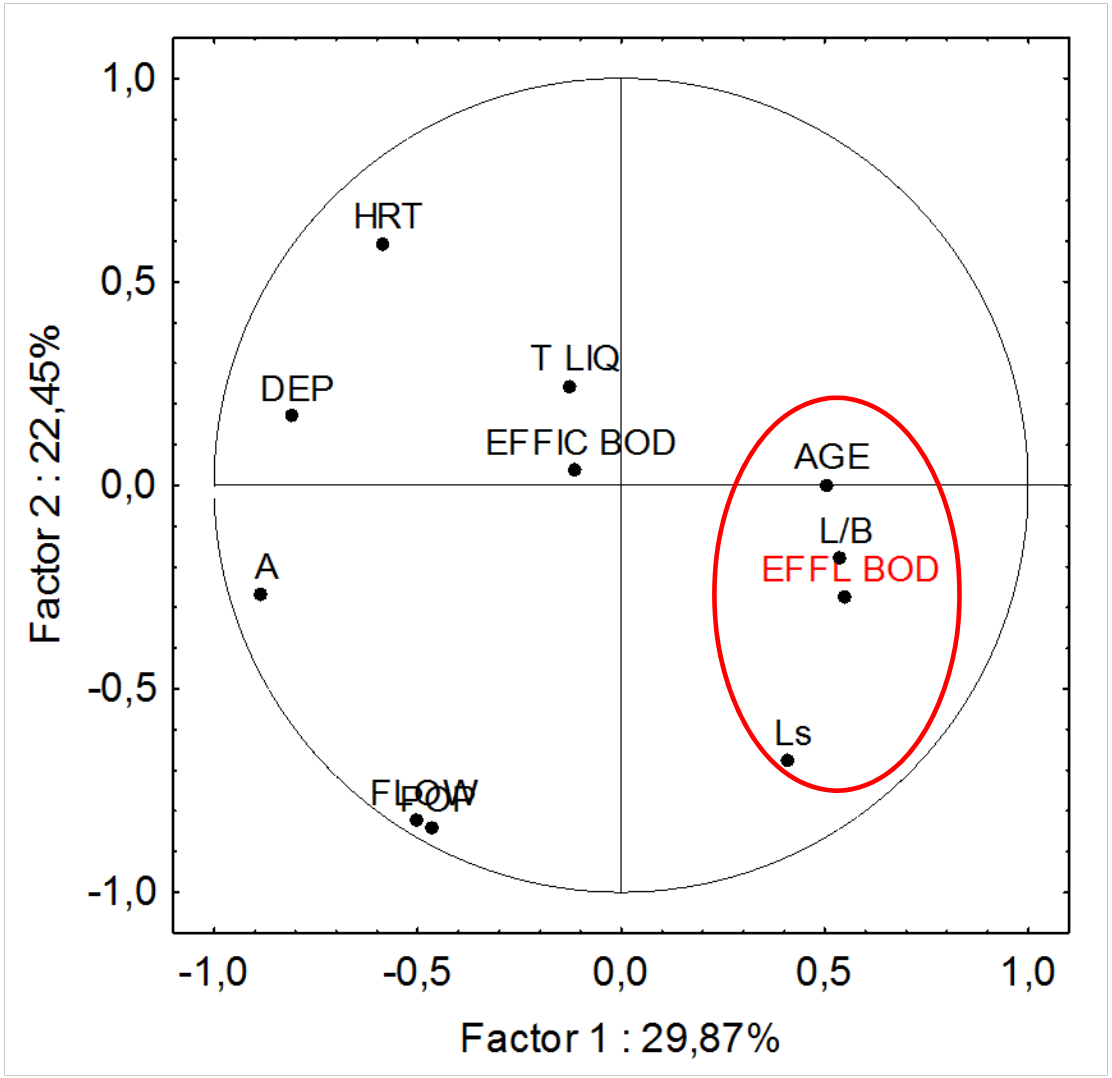
Over 15800 operational data from the 73 facultative ponds were used in the multivariate statistical analysis, comprising 11 design and operational parameters

Summary of the PCA results including the loadings (participation of the original variables in the new ones) and the eigenvalue of PC

Variable	PC1	PC2	PC3	PC4
EFFLBOD	**0.552**	-0.274	**-0.589**	-0.076
EFFICBOD	-0.111	0.034	**0.912**	-0.179
Flow	-0.499	**-0.827**	-0.009	0.076
Hydraulic retention time	**-0.582**	**0.590**	-0.064	0.131
Surface BOD loading	**0.412**	**-0.680**	0.193	-0.256
Area	**-0.883**	-0.270	-0.086	0.266
Depth	**-0.808**	0.166	-0.106	0.100
Geometry (length/breadth ratio)	**0.540**	-0.183	0.159	**0.593**
Temperature of the liquid	-0.123	0.240	0.050	**0.299**
Population served by the ponds	-0.464	**-0.842**	0.024	0.131
Age of the pond at the time of the results	**0.506**	-0.001	0.148	**0.622**
Eigenvalue	3.3	2.5	1.3	1.1
% Total variance	**29.9**	**22.5**	11.7	10.0
Cumulative %	29.9	52.3	64.1	**74.1**

Results and discussion

Score and loading of ponds data on the bidimensional plane defined by the first two principal components (PC1 and PC2) accounting for 53.4% of the total variance



Scores and loadings of the first two PCs in the correlation circle reflect the main groupings in the data set

As expected, higher HRT, breadth and retention time

Old ponds present higher net depth due to sludge accumulation, leading to higher effluent BOD concentrations

Ls (organic loadings) are correlated with organic overload close to the pond inlet

reducing the volume

Results and discussion

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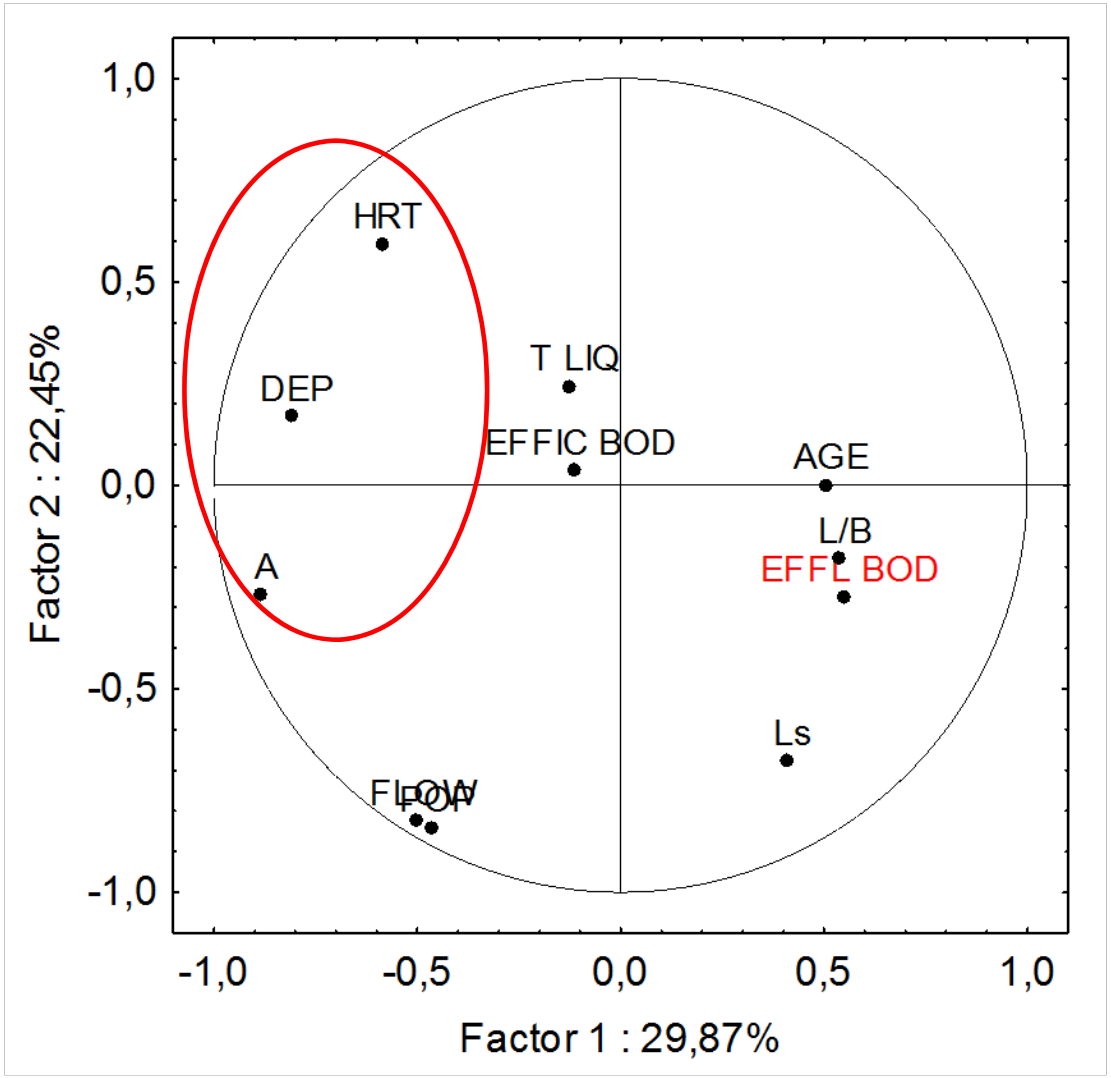

HRT, area and depth presented negative correlation to effluent BOD concentration

Ponds with higher depths are associated with larger volumes and with possibly microorganisms to higher retention times, having more room for matter sludge storage

Higher retention times give more time for the

Conclusions

- Many ponds are facing difficulties in achieving a satisfactory performance, as compared with the expected performance stated in the literature

- Other studies also relate that many ponds operating in other tropical climate countries have been performing below the required standards, due to lack of proper operation and maintenance

Conclusions

- There are no technological limitations for biological treatment in Brazil: other non-technical factors could be influencing the ability of the processes to meet expected levels of performance

- It was observed a wide variation, from pond to pond, of the monitoring practice and the operating conditions and physical characteristics

Conclusions

- PCA allowed the reduction of the 11 variables to four significant PCs that explain 74.1% of the variance (information) of the original data set

- It was verified the effect of the parameters organic loading, L/B ratio, hydraulic retention time, area and depth on the effluent BOD concentration

Conclusions

- Higher surface BOD loading, age and length/breadth ratio lead to higher effluent BOD concentration

- The increase of HRT, area and depth had positive influence on ponds performance

Acknowledgments

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MINISTÉRIO DA CIÊNCIA E TECNOLOGIA

And municipal service providers

Thank you for your attention

Maracanaú WWTP – CE/Brazil - 1 AP + 1 FP + 3 MP (100 ha)