Temporal and spatial variations of dissolved oxygen, pH, and chlorophyll *a* in waste stabilization pond system at high altitude (Ecuador).

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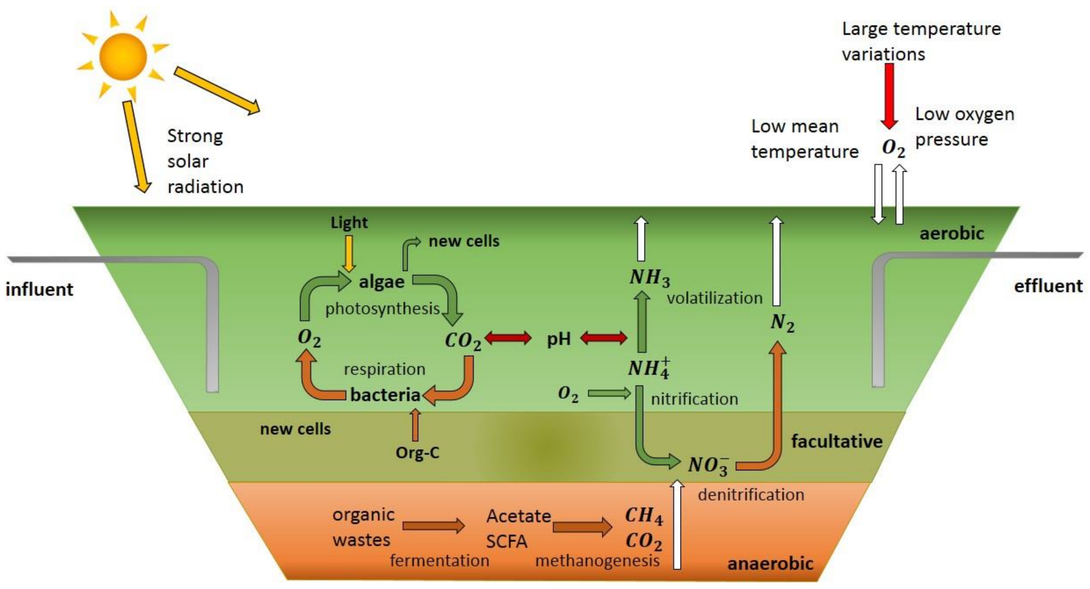
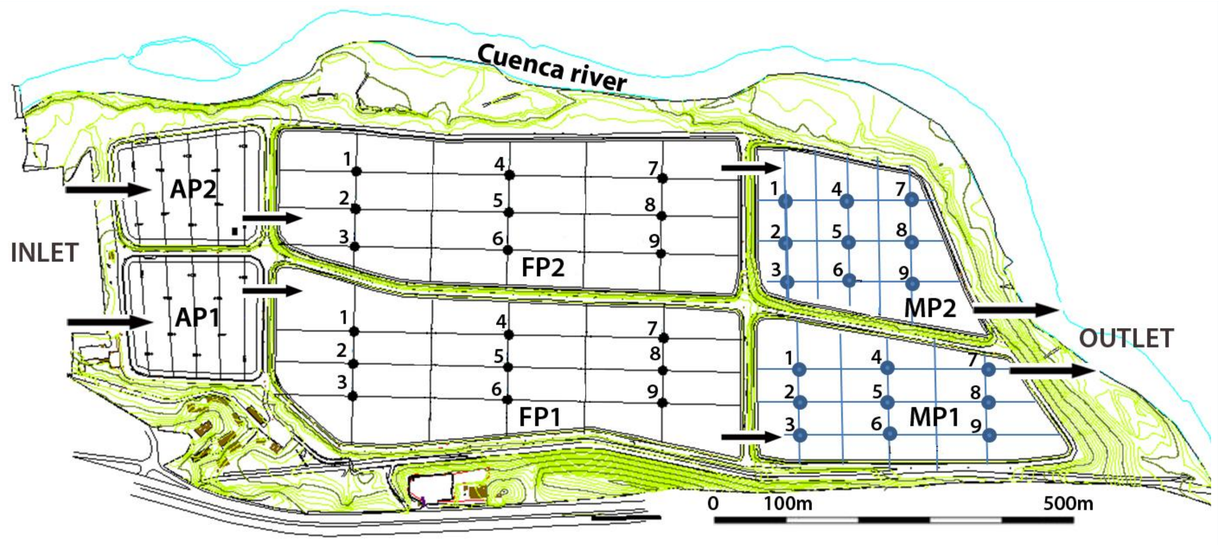
BACKGROUND

- Simplicity, low cost, robustness and high efficiency.
- The performance of WSPs is dependent on climatic conditions.
- Extreme climatic conditions at high altitude: strong solar radiation, low oxygen pressure, low mean temperatures, etc.



MATERIALS AND METHODS



- Located at Ucubamba, 2560 m.a.s.l, 2 identical flow lines: an aerated pond (AP), a facultative pond (FP) and a maturation pond (MP).
- Samples were taken at 9 different locations at two depths, 30 cm below the water surface and 15 cm above the sediment layer.

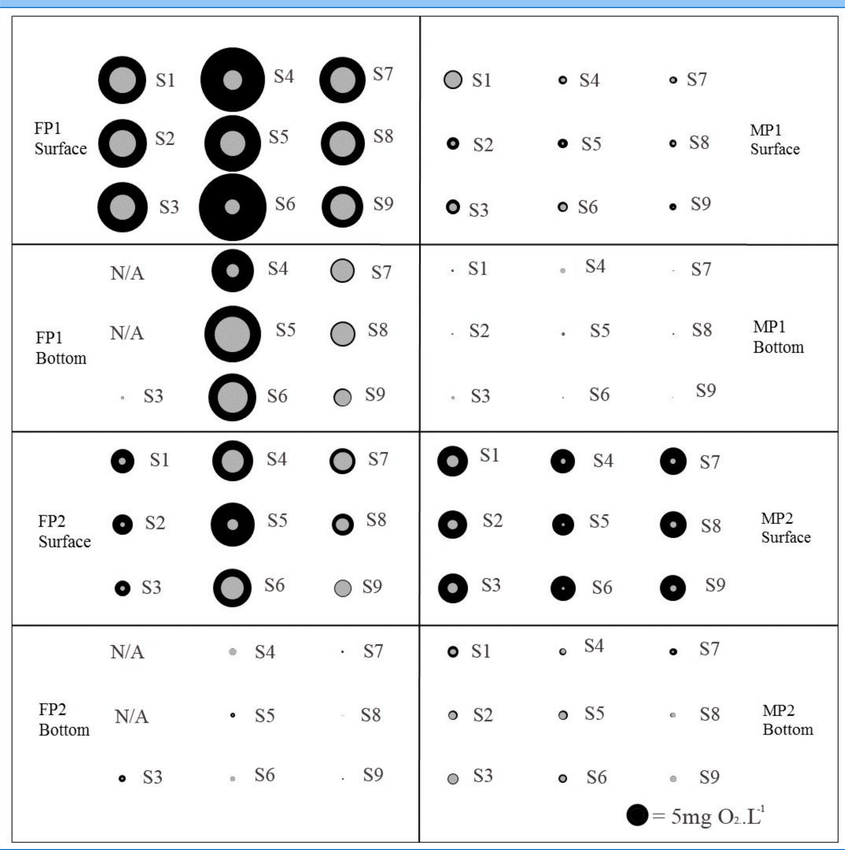
RESULTS AND DISCUSSIONS

1. Variations among the ponds

- FP1: approx. 20% higher pollutants.
- DO, pH, and chlorophyll *a*: high variability between 2 depths.
- Higher concentration of chlorophyll a in FPs.

Pond	DO (mg.L^{-1})	Chlorophyll *a* (µg.L^{-1})	BOD_5 (mg.L^{-1})	TP (mg.L^{-1})	TKN (mg.L^{-1})	TS (mg.L^{-1})
FP1 Surface	12.8 ± 2.0	471 ± 15	42 ± 2	3.1 ± 0.2	30 ± 1.3	385 ± 30
	16.1 ± 2.4	500 ± 0	38 ± 7	2.4 ± 0.6	24 ± 2.0	377 ± 126
	6.5 ± 4.1	360 ± 120	46 ± 7	2.9 ± 0.1	27 ± 1.7	388 ± 64
FP1 Bottom	10.8 ± 5.4	322 ± 170	43 ± 2	3.4 ± 0.7	29 ± 2.8	424 ± 105
	8.1 ± 5.9	433 ± 102	38 ± 10	2.3 ± 0.3	24 ± 2.1	359 ± 44
	2.3 ± 2.5	275 ± 166	28 ± 3	2.2 ± 0.1	24 ± 2.0	315 ± 27
FP2 Surface	4.8 ± 2.5	313 ± 122	32 ± 4	2.7 ± 0.1	26 ± 0.3	332 ± 33
	8.9 ± 4.2	482 ± 36	30 ± 7	2.3 ± 0.2	24 ± 0.3	314 ± 31
	5.0 ± 2.8	375 ± 135	31 ± 9	2.6 ± 0.7	24 ± 0.3	371 ± 64
FP2 Bottom	0.5 ± 0.4	260 ± 122	27 ± 3	3.0 ± 0.1	26 ± 0.7	338 ± 10
	1.5 ± 1.2	389 ± 145	25 ± 1	2.2 ± 0.3	23 ± 1.0	303 ± 29
	0.7 ± 0.6	81 ± 159	25 ± 2	2.4 ± 0.3	23 ± 0.4	325 ± 43
MP1 Surface	1.6 ± 0.8	166 ± 43	19 ± 1	2.5 ± 0.0	25 ± 1.5	300 ± 4
	3.3 ± 2.3	325 ± 95	22 ± 1	1.8 ± 0.1	23 ± 1.0	259 ± 5
	2.4 ± 0.6	111 ± 32	18 ± 2	2.3 ± 0.0	23 ± 0.7	259 ± 6
MP1 Bottom	0.5 ± 0.5	175 ± 130	19 ± 1	2.6 ± 0.1	26 ± 2.1	298 ± 4
	0.3 ± 0.2	112 ± 166	24 ± 5	1.9 ± 0.3	24 ± 0.3	292 ± 45
	0.7 ± 0.7	200 ± 158	20 ± 3	2.3 ± 0.0	23 ± 0.6	264 ± 9
MP2 Surface	7.0 ± 1.3	275 ± 45	23 ± 4	2.4 ± 0.0	26 ± 1.5	307 ± 7
	6.7 ± 1.0	210 ± 65	15 ± 0	1.9 ± 0.1	21 ± 0.3	262 ± 11
	4.4 ± 0.3	170 ± 42	17 ± 2	1.9 ± 0.1	21 ± 1.0	284 ± 5
MP2 Bottom	2.3 ± 1.5	63 ± 42	17 ± 4	2.5 ± 0.1	25 ± 2.3	291 ± 33
	2.7 ± 0.4	71 ± 25	18 ± 1	2.5 ± 1.2	20 ± 0.9	263 ± 8
	0.7 ± 0.6	59 ± 104	14 ± 1	2.0 ± 0.1	22 ± 0.4	285 ± 9

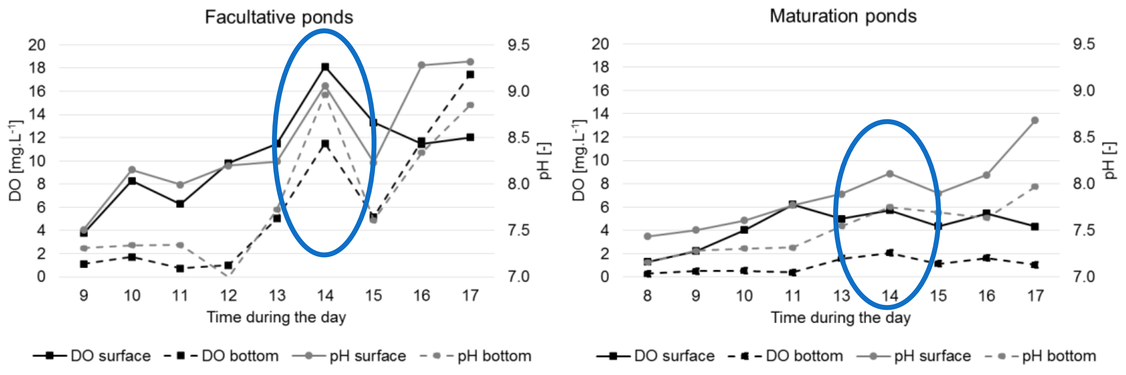
2. Spatial variations within the ponds



- 2 depths: BOD_5, nutrients, and TS: homogenous. DO and chlorophyll *a*: various.
- FP1: 5 mg O_2.L^{-1} higher but MP1 ≈1/2 MP2.
- O_2 ↓ 5 times in the 1st line.
- Highest O_2 in FPs: middle, MPs: input area

3. Diurnal variations

- Highest DO and pH between 1 pm and 3 pm
- Highest O_2: almost 20 mg.L^{-1}



4. Insights for pond design, monitoring, and operation

- WSPs at high altitude requires longer HRT, meaning bigger size.
- Monitoring campaigns at different climatic conditions and full range of expected influent compositions.
- A sufficient removal of accumulated sludge is recommended

OBJECTIVES

- To investigate how high altitude properties impact on the behaviour of the pond system via the effects of wastewater constituents and climatic conditions within and among the pond treatment system
- To obtain adequate strategies for designing, monitoring, and operation high altitude pond treatment system.

CONCLUSIONS

- High altitude caused lower removal efficiencies.
- Lower mean temperature → more sensitive to alterations in pollutant loadings
- DO, pH, and chlorophyll *a* had vertically and horizontally different patterns within and among ponds.
- Adequate strategies for design, monitoring, and operation

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