Oxygen transfer in a gas-liquid system : kinetic influence of water salinity

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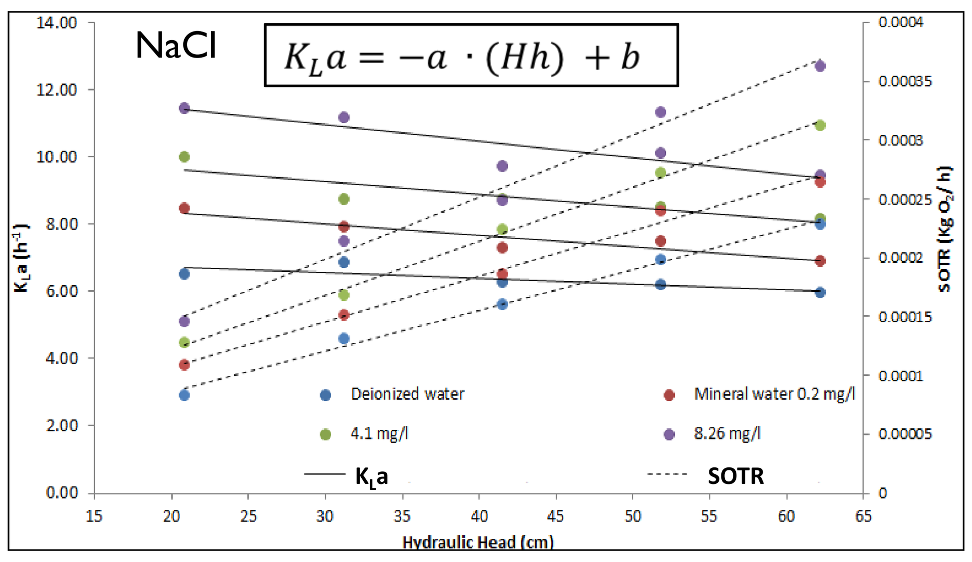
We have investigated the influence of hydraulic head, air-flow with different salts on the oxygenation kinetics by a 4-liters water jacketed system at controlled temperatures.
The study clearly highlight the need to carefully study the oxygen diffusion coefficients in complex media. This condition is necessary to describe and to model properly the gas–liquid mass transfer phenomena.

Introduction

The gas liquid mass transfer, with the gas as dispersed phase, plays a key role in wastewater treatment as controlling the oxygen available for the microorganisms metabolism [1-2].
The performance of the purification process is directly linked to the efficiency of the oxygen transfer phenomenon, that can be analyzed by means of kinetic study of oxygen dissolution from the oxygen mass transfer coefficient (K_La) [3] and oxygen transfer rate (SOTR) [4].
This study is dedicated to an accurate evaluation of thermodynamic and kinetics aspects in the water oxygenation process by a stirred, submerged aerated 4-liters system.
The operational conditions has been optimized by studying the influence of hydraulic head, air flow and salinity of water using an optical oxygen sensor.
Concerning the thermodynamic phase equilibria, experimental and modelling results are obtained from different binary systems (water/air) and ternary systems (water/air/salts).

Results & Discussion

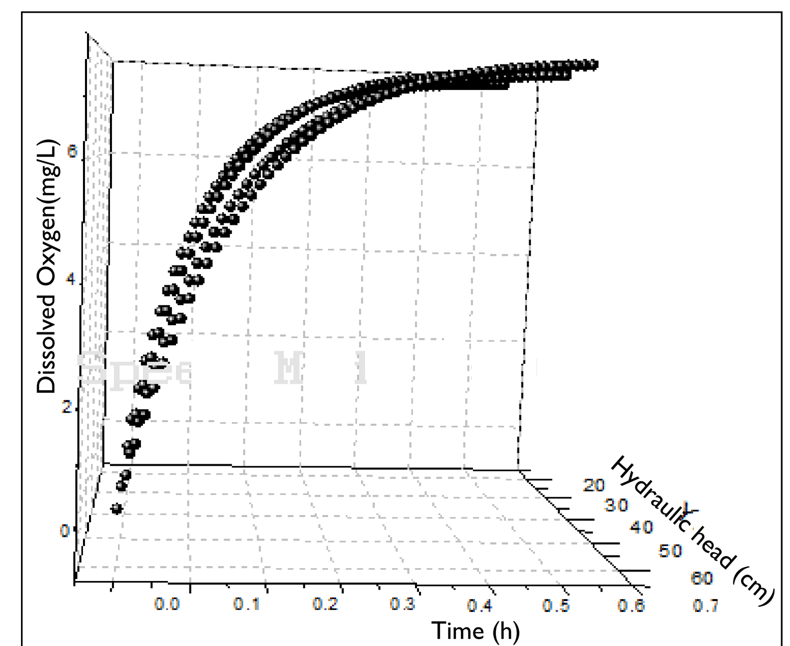


$$\frac{dC}{dT} = \boldsymbol{K_L a}(C_S - C_t) \qquad \boldsymbol{K_L a_{(20°C)}}\,(h^{-1}) = \frac{K_L a_{(20°C)}}{\theta^{(T-20)}} \qquad \theta = 1.024$$

$$\boldsymbol{SOTR}\left(Kg\frac{O_2}{h}\right) = \boldsymbol{K_L\, a}_{(20\,°C)}\,(h^{-1}) \cdot \boldsymbol{V}(m^3) \cdot \boldsymbol{C_s}\,(H_2O,\ 20°C, 1\,atm)$$

Parameters obtained with air flow of 0.2 l/min

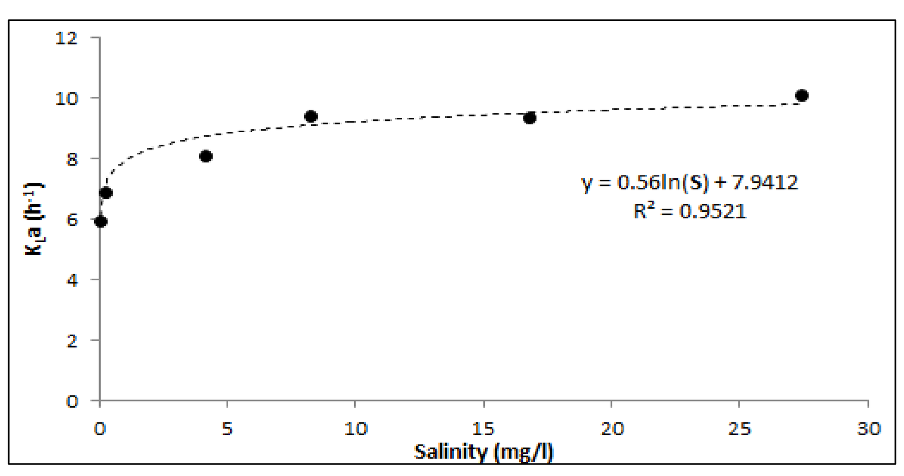
Hydraulic Head (cm)	14.6	20.8	31.2	41.5	51.8	62.2
Volume(l)	0.973	1.39	2.085	2.78	3.475	4.17
K_La (23.5°C) (h^{-1})	9.700	9.219	8.600	7.910	8.156	7.495
K_La (20°C) (h^{-1})	8.927	8.484	7.915	7.280	7.506	6.898
SOTR	7.991E-05	1.085E-04	1.518E-04	1.862E-04	2.400E-04	2.646E-04



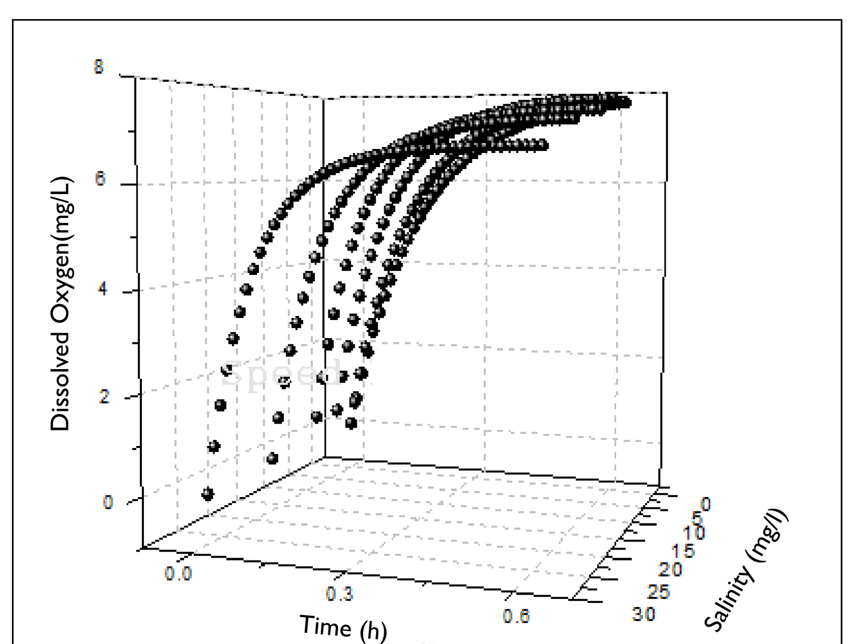
$$C(t) = C_S - (C_S - C_0)e^{-K_L at}$$

❖ **With different salinity at the same air-flux**:

Oxygen mass transfer coefficient (K_La) and the Standard Oxygen Transfer Rate (SOTR) show linear dependences at different hydraulic head (Hh).
To low kinetics correspond better oxygen transferring.



Influence of salinity on the mass transfer coefficient K_La at the same hydraulic head (62.2 cm).



$$C(t) = C_S - (C_S - C_0)e^{-K_L at}$$

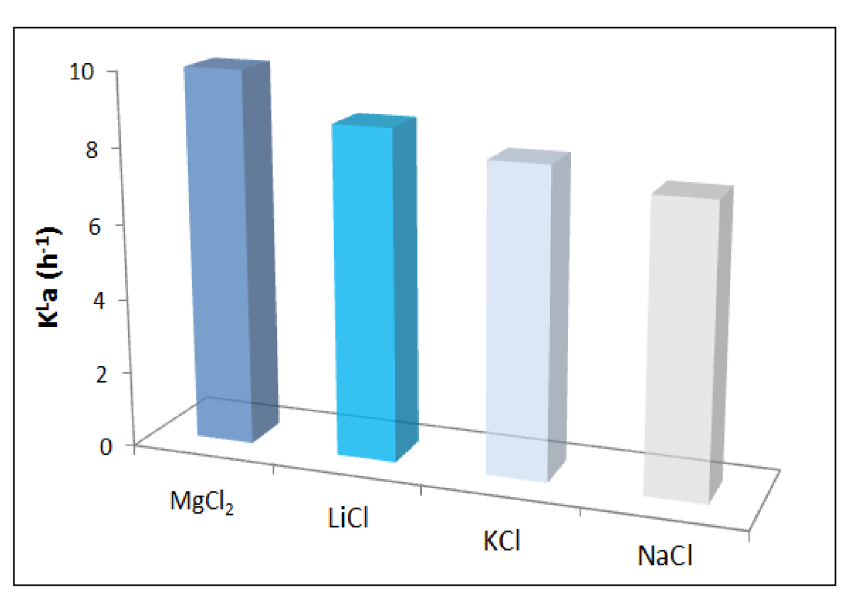
Oxygenation kinetics as function of salinity (NaCl) at the same hydraulic head (0.2 l/min)

Mass transfer coefficient and SOTR with different salinity (NaCl) at the same hydraulic head

Salinity (mg/l)	0	0.2	4.1	8.26	16.8	27.4
K_La (23.5°C) (h^{-1})	6.470	7.495	8.852	10.278	10.200	10.991
K_La (20°C) (h^{-1})	5.954	6.898	8.146	9.460	9.388	10.115
SOTR ($KgO_2 h^{-1}$)	2.284E-04	2.646E-04	3.125E-04	3.629E-04	3.601E-04	3.881E-04
Cs (mg/l)	8.027	8.003	7.906	7.649	7.223	6.873

❖ **To the increasing of salinity correspond**:

Decreasing of saturation concentration
Increasing of oxygen mass transfer coefficient



Influence of salt on the mass transfer coefficient K_La at the same salinity and hydraulic head (62..2 cm).

❖ **At the same salinity with different chloride salts**:

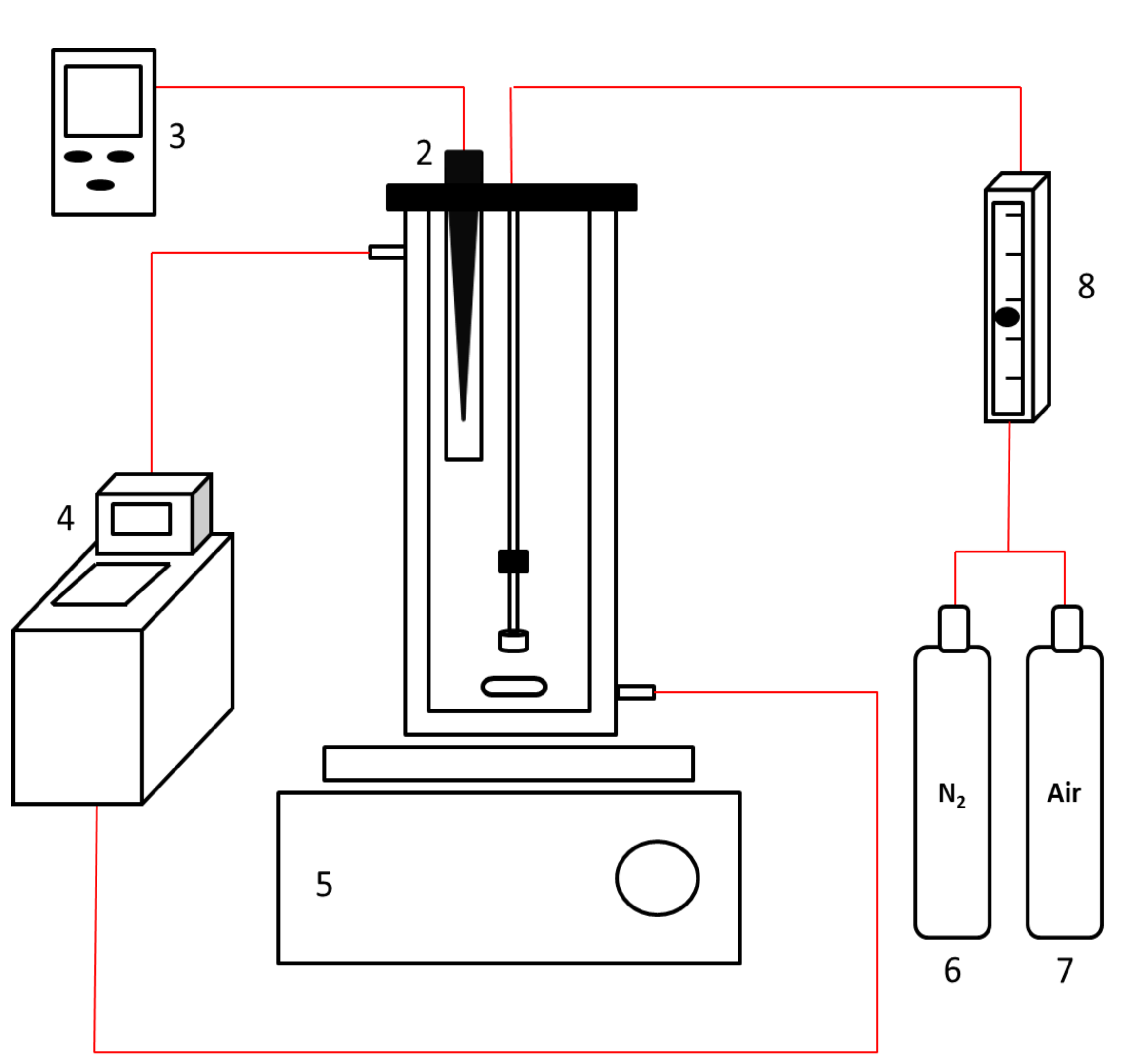
The oxygenation kinetics change with the type of salt showing dependence of cation

The saturation concentration Cs is similar for all salts.

Salt	$MgCl_2$	LiCl	KCl	NaCl
K_La (23.5°C) (h^{-1})	22.511	19.611	17.848	15.510
K_La (20°C) (h^{-1})	20.718	18.049	16.426	14.275
SOTR (Kg O_2/h)	0.000795	0.000692	0.000634	0.000548
Cs (mg/l)	7.908	7.940	7.944	7.812

Parameters obtained with salinity of 4.1 mg/l and hydraulic head of 62.2 cm

Methods



(1) Vessel with Termostated Jacket;
(2) Luminescent Dissolved Oxygen Probe (HACH, IntelliCAL™ LDO101);
(3) Acquisition System;
(4) Thermo-regulation at 23.5°C;
(5) Magnetic Agitator;
(6) Nitrogen supply;
(7) Air supply
(8) Gas flowmeter.

Bibliography

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