IMPACT OF DOMESTIC AND OTHER WASTE EFFLUENTS ON EQUILIBRIUM OF DISSOLVED OXYGEN IN STAGNATED WATER BODIES

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Introduction

Oxygen is a necessary element to all forms of life. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As DO levels in water drop below 5.0 mg/l, aquatic life is put under stress; the lower the concentration, the greater the stress (Gillibrand, et al, 1996). Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills. DO is probably the single most important water quality factor that pond managers need to understand. Oxygen dissolves in water at very low concentrations. Our atmosphere is around 20% oxygen or 200,000 ppm but seldom will a pond have more than 10 ppm oxygen dissolved in its' water.

While systems in nature appear simple on the surface, we know they are quite complicated when examined closely. DO is no exception, and the three factors which govern its concentration in a stagnant water body or river are pressure, salinity and temperature. Gas solubility increases with increasing atmospheric pressure but with decreasing salinity and temperature. The widespread degradation of aquatic ecosystems is observed in and around Kalmunai MC, which is suffering from critical water shortages and chronic water pollution. Aquatic flora and fauna have been seriously degraded. The gases dissolve in liquids to form solutions. This dissolution is an equilibrium process and the equilibrium between oxygen gas and dissolved oxygen in water is,

$$O_{2\,(aq)} <===> O_{2\,(g)}. \qquad (1)$$

The equilibrium constant, K, for this equilibrium is given as $K = p(O_2)/c(O_2)$ where, p is the partial pressure of the gas, c is its molar concentration, and K is the Henry's law constant on the molar concentration scale and is a temperature dependant (Rolf Sander, 1999). Equation (1) shows that the concentration of a solute gas in a solution is directly proportional to the partial pressure of that gas above the solution. Measuring the factor affecting coefficient (FAC) of the DO in stagnated water bodies at Kalmunai **(S1)** and Ninthavur **(S2)** and comparing these distributions would give a better understanding of the exchange of salt and nutrients in both systems, and in turn can evaluate their effects on water quality. Therefore the objectives of this study was (i) to assess whether DO levels in S1 and S2 were limited by COD and Nutrient level, and (ii) to analyze the dynamic equilibrium of oxygen through FAC in both water bodies.

Methodology

Water samples were collected from two randomly selected stagnant water bodies in this region. Station S1 was having an open water column depth of 2.5m, which is 1000 m offshore from the Kalmunai shoreline. Station S2 with water column depth of 1.5 m was 100m from the shoreline of Ninthavur local government building. Both the above stations were heavily infested by a stationary water hyacinth and receive wastes from nearby hospital, domestic and municipal sources, agriculture runoff and poultry farm. The water samples were collected between 09:00 am and 12:00 noon, transferred into sterile plastic containers and transported to the laboratory keeping them within ice cooled regiform boxes to avoid temperature loose. The physical, chemical and biological parameters of the water samples were performed on the same day of water collection. Samples were collected twice a month, between June and November 2011.

Analysis of physico-chemical and biological parameters: The *pH*, electrical conductivity (*EC*), *DO*, salinity and temperature (*T*) values of the water samples were determined *in situ* using portable meters. The phosphate (PO_4^{3-}-P), nitrate (NO_3-N), ammonia (NH_4^+) and sulfate ion concentrations were measured at the laboratory using spectroscopic methods (Hach, DR/2010). COD was analyzed using Eco 6 thermoreactor (Velp Scientifica, Europe) to digest the water samples. *Escherichia* coliform (44.5°C) and total coliform (35±O.5°C) were enumerated, as the bio indicator organisms (APHA, 1998).

Discussion and Conclusion

The station S1 (Karaivagu water body in Kalmunai) have been polluted primarily due to urbanization through domestic, hospital, market, rice mil activities, animal dumping and agriculture runoff. On the other hand, the station S2 (Kalappu water body in Ninthavur) have been polluted due to domestic wastewater and agriculture runoff. The physical parameters of the stagnant water bodies such as, the pH, temperature and the concentration of oxygen in the gases phase and the liquid phase are given in Table 1. The pH change was within the base limits, However relatively higher and lower values (6.18 & 5.93) were observed at S1 and S2 during T4 and T1 sampling analysis, respectively. Temperature was also consistent but higher (31.80) and lower (28.20) values were observed at T2 sampling analysis in both stations. The concentration of saturated oxygen level was exhibiting a higher value of 0.68 mmol/l at S2 during T2 period while a lower value of 0.27 mmol/l at S1 during T1. It was observed from the temperature analysis that a lower and a higher temperature readings were obtained during T2 and T1 at S2 and S1, respectively.

Table 1: Summary of the measured and calculated physical properties for stagnant water bodies

Station	Time	Nutrient level mean ± SD	COD mean ± SD	Salinity mean ± SD	FAC mean ± SD
Station 1	T1	14.73 ± 10.66	617.00 ± 140.56	1.00 ± 0.61	0.19 ± 0.06
	T2	13.22 ± 8.65	484.00 ± 161.92	0.92 ± 0.71	0.24 ± 0.09
	T3	12.43 ± 9.75	596.00 ± 124.37	0.76 ± 0.58	0.24 ± 0.16
	T4	10.59 ± 14.15	541.00 ± 157.34	0.82 ± 0.54	0.26 ± 0.21
Station 2	T1	4.69 ± 1.19	645.00 ± 111.13	1.70 ± 0.36	0.39 ± 0.12
	T2	3.58 ± 2.15	591.00 ± 239.85	1.54 ± 0.63	0.61 ± 0.31
	T3	4.54 ± 1.08	488.00 ± 148.69	1.20 ± 0.51	0.56 ± 0.22
	T4	4.62 ± 1.60	575.60 ± 121.31	1.24 ± 0.56	0.44 ± 0.14

Table 2: Factor affecting coefficient and physico-chemical properties for the water bodies

Station	Time	Nutrient level mean ± SD	COD mean ± SD	Salinity mean ± SD	FAC mean ± SD
Station 1	T1	14.73 ± 10.66	617.00 ± 140.56	1.00 ± 0.61	0.19 ± 0.06
	T2	13.22 ± 8.65	484.00 ± 161.92	0.92 ± 0.71	0.24 ± 0.09
	T3	12.43 ± 9.75	596.00 ± 124.37	0.76 ± 0.58	0.24 ± 0.16
	T4	10.59 ± 14.15	541.00 ± 157.34	0.82 ± 0.54	0.26 ± 0.21
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	T4	4.62 ± 1.60	575.60 ± 121.31	1.24 ± 0.56	0.44 ± 0.14

On the other hand dissolved oxygen T2 was given higher value 0.13 mmol/l at S1 while it was showed low value 0.05 mmol/l at S2 during T1. The DO was compared with other parameters such as Nutrients level, salinity and Organic content in the water bodies. The mean factor affecting coefficient (FAC), salinity, nutrient level and COD are tabulated in table 2.

The FAC was calculated based on the Henry's low that is the difference between the concentration of the oxygen in gas phase and the liquid phase and it was found to be within the range of 0.35 to 5.50 mmol l^{-1} for all the water bodies. The affect of salinity on O_2 (0.05-0.13 mmol/l), S1 data was split into S2 that is different significant negative correlation of DO vs. Salinity was observed with higher R^2 values (S1: R^2 =0.7293, S2: R^2 = 0.7713). The analysis of the COD with the concentration of the DO exhibit the higher organic content (617.00 mg/l) had low DO (0.07 mmol/l) concentration during T1 and T3 at station1 whereas it was lowed (484.00 mg/l) during T2 showed higher DO (0.13 mmol/l) concentration. The similar phenomenon was observed at station 2 but different in level.

This variation clearly described by the significant negative correlations of DO vs. COD with higher R^2 value (S1: R^2 =0.6532, S2: R^2 = 0.8183). Therefore, higher levels of DO consumer can take major role to this significant change. Nutrient enrichment can alter the rate of sedimentation of organic matter, and therefore the concentration of dissolved oxygen in bottom waters (Howarth et al. 2002). It was varied with DO concentration such as at station 1 exhibit higher level (14.73 mg/l) of nutrient content during T1 period with lowering the DO concentration (0.07 mmol/l) and the opposite is also true with nutrient level (10.59 mg/l) and second lowest DO concentration (0.10 mmol/l). However, S2 having the low level of nutrients compare with station 1 and significant negative correlation with higher R^2 value for DO vs. Nutrient level (S1: R^2 = 0.6466 and S2: R^2 = 0.7321) because of the Nutrient rich effect at these stations can remove the feasible space for the dissolution of the oxygen gas.

The DO depletion was lead by COD (enrichment of organic matters), nutrients level, nitrification and salinity of the stagnant water bodies. The laundry activities radically enhance the ionic level in the stagnant water bodies and the distance between stagnant water locations and the paddy field is significantly affect nutrient levels in the stagnant water bodies. The organic matter found in these water bodies highly influences on the development of coliform bacteria as well as sulfur reducing bacteria. As a result DO concentration depleted considerably and fish like organisms getting suffocate. Further, during the dry sessions, nature of these water bodies are highlighted due to higher activity of the above bacteria that will produce a malodorous environment to mosquitoes and rotten egg smell thorough the decomposition of the organic matter.

References

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