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URBAN WETLANDS – CO_2 SINK OR SOURCE? A CASE STUDY ON THE AQUACULTURE PONDS OF EAST KOLKATA WETLANDS

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ABSTRACT

East Kolkata Wetland (EKW) is an urban or peri-urban wetland located on the outskirts of the Kolkata City which performs multi-facet activities, carbon sink being one of them. The raw waste from the city is naturally treated in this wetland system, however, the aquaculture ponds situated in these wetlands which make use of this waste water for fishery is rarely studied. The present study aims to see whether the aquaculture ponds of EKW complex are acting as a source or a sink. Air-water carbon dioxide (CO_2) flux was estimated for three consecutive seasons in a year and it was found that the system is acting as a CO_2 source in all the three seasons. The average CO_2 flux was 4184 µmol m^{-2} h^{-1}, 2897 µmol m^{-2} h^{-1} and 438 µmol m^{-2} h^{-1} during pre-monsoon, monsoon and post-monsoon season respectively. Effective treatment of sewage water and avoiding widespread eutrophication could lead to lowering of CO_2 effluxes or may turn it to a sink as well.

INTRODUCTION

The era of global warming and increased emission of greenhouse gases can be marked by the beginning of the industrial age. It is also true that under several conditions, natural ecosystems can be equally responsible for CO_2 emission like any other anthropogenic activities which continuously release heat-trapping gases in the process of development. Wetlands are such unique compartments of the natural ecosystem, which acts as a potential carbon sink and plays a crucial role in the mitigation of climate change. However, the functioning of these ecosystems may convert them into a source under specific conditions and reverse their role (Kayranli *et al*., 2010). More focus should be administered on short-term as well as long-term carbon balance in such delicate ecosystems, as they are frequently affected by dynamic environmental conditions such as hydroperiod, water level depth, frequency and intensity of precipitation and air-water temperatures (Anderson *et al*., 2016).

Wetlands show dual nature under certain circumstances, mainly anthropogenic activities, by sequestering carbon in form of biomass and also releasing a major amount of Greenhouse gases (Singh, 2016). They release approximately 1.45×10^{11} kg CH_4-Cyr^{-1} into the atmosphere, which amounts to nearly 25% of the total emissions combining anthropogenic and natural sources (Cao *et al*., 1998). These marshy vegetative lands have high gross primary productivity and along with the anaerobic surroundings, they inhibit decomposition process, thereby preserving the sequestered carbon within the soil layers (Anderson *et al*., 2016). The wetlands consist of an anaerobic subsurface zone of methane production as they capture carbon dioxide from and release methane into the atmosphere and also act as an overlying aerobic zone of methane oxidation (which is mostly performed by methanotrophic bacteria), thereby transferring carbon dioxide and methane to atmosphere through diffusion, ebullition and arenchymous transfer (Whalen, 2005). Deep wetlands are those which are permanently or semi-permanently inundated, with standing or slow-moving water (lacustrine system) (Maynard *et al*., 2017). Talking about their role as a carbon source and sink, they are able to capture carbon dioxide from and release methane into the atmosphere (Whiting and Chanton, 2001). The carbon storage and sequestration capacity of wetlands are assumed to be the highest compared to any other terrestrial ecosystems (Australian Government, 2012). Though wetlands cover a very

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small area, approximately 6-9% of the total global area (WWF Global, 2017), (Pant *et al*., 2003), but owing to its high productivity, they are able to capture around 35% of the total terrestrial carbon (approximately 15×10^{14} kg (Kayranli *et al*., 2010). Thus, a relatively small area in case of wetlands is capable of long-term carbon sequestration capacity (McDermott, 2009). The ratio of methane release and carbon dioxide consumption in wetlands determines the overall carbon exchange balance with the atmosphere (Kayranli *et al*., 2010). The aggregate of both methane and carbon dioxide flux determines whether the countervailing process makes a wetland an overall contributor of greenhouse gases.

The biogeochemical cycles in wetlands represent 15% of the terrestrial organic matter loss to the oceans, thus with a major potential to combat climate change through sequestration as a result of the significant amount of accumulation (NCSU Water Quality Group, 2017). Efficiency in carbon sequestration is due to high primary productivity and lower decomposition rates in soil (anaerobic soil and low oxygen supply) (Commonwealth of Australia, 2012). Gaseous end products are formed in both aerobic and anaerobic conditions, where carbon dioxide and methane are generated in an anaerobic condition and only carbon dioxide is formed under aerobic conditions (Kayranli *et al*., 2010). In constructed wetlands, used for treating wastewaters, the process of methanogenesis is an important decomposition process which may act as a potent source of methane into the atmosphere. Ramsar convention has a prescribed water level for the minimum flow in the wetlands that is the depth of the wetlands at low tides does not exceed six meters (Ministry of Environment, Forest and Climate Change, 2018), this dependency on water availability and precipitation makes the ecosystem and the associated species more vulnerable to climate change (Kundu, 2011). It has been studied that under warmer and wetter conditions, more gases are emitted from wetlands and as the tropical wetlands are continuing to warm, they are turning into potent greenhouse gas source to the atmosphere (University of Guelph, 2014). Coastal habitats are capable of storing carbon in their soil up to 50 times more than tropical forests and 10 times more than temperate forests, because most of the carbon storage in forest ecosystem takes place in above-ground vegetation, whereas temperate forests and wetlands are inclined towards below-ground storage. Carbon flux measurement study was done in restored wetlands on Twitchell Island, Calif in 2003, which showed that early production rates were higher compared to the later stages of restoration. On average, the restored wetland was acting as a small net source of Carbon and methane's greater greenhouse potency was indicated to exceed the potential cooling by the uptake of carbon dioxide during photosynthesis. The results showed that warming potential of during 2010-2011 periods was way more to counteract the potential cooling measured during the earlier stages when the younger wetlands were times more productive (Anderson *et al*., 2016). Eutrophication process is studied extensively, for its role in carbon sequestration is major, instead of having environmental implications. Being eutrophic may turn a carbon source into a sink due to the CO_2 disequilibrium caused by extreme primary production also helps in absorption of both landscape and atmospheric carbon (Pacheco *et al*., 2013). A study by (Balme and Downing, 2011) studied that high-nutrient lakes relatively small in size and in oxygen-rich condition, could act as atmospheric carbon dioxide uptake sites.

Wetland soils also play an important role in carbon flux scenario and the soil CO_2 flux being the second largest terrestrial carbon flux unit, is one of the controlling factors of global carbon budget, owing to its high sensitivity to global temperature change. Studies have shown that soil temperature and CO_2 efflux are directly proportional to each other (Tang *et al*., 2006). This is validated by several other authors as they have reported that emission of carbon dioxide increases with increased atmospheric temperature as well as under drained condition (Scholz, 2011). This can be justified in case of Great Dismal Swamp where peat takes up atmospheric methane when the water table is below peat during the dry season and releases methane in a well-saturated condition (Harris *et al*. 1982), (Kayranli *et al*., 2010). The situation worsens as the stored carbon dioxide in biomass decays once the wetland starts drying up. The study shows that 1°C rise in temperature may cause 10% loss of soil organic carbon in areas having an annual mean temperature of 5°C and 3% loss of organic carbon at 30°C. Effect of global warming in decreasing the soil organic carbon content is indicative of the study, also indicating a positive feedback in the global Carbon cycle (Kirschbaum, 1995). Change in temperature and precipitation also changes the way and amount of gaseous carbon and DOC, having an impact on the global carbon cycle (Kundu, 2011). (Chanda *et al*., 2011) has also studied the interrelationship between high soil temperature and maximum flux rates and found that on an average mangrove soils emits 242.51 mg CO_2 $m^{-2}hr^{-1}$ at a maximum temperature in day-time. Alteration and destruction of wetlands by the removal of vegetation cover may result in a decrease in carbon fixation, thus resulting in a net carbon release from the wetlands. Such conversions in natural ecosystem play a significant role in the global carbon cycle (Cruz, 1986). Global carbon emission potential for re-wetting of peatlands has been considered an effective strategy but study by Wetland International showed that this process only reduced net emissions by half and also that only in a fraction of peatlands rehabilitation is feasible (Perceval, 2014).

However, the fact remains that the system which promotes carbon sequestration also acts as the largest natural source of methane emission in the atmosphere. Hence it has become imperative to study and analyze the source-sink potential of all the wetlands to understand properly the carbon dynamics of such a delicate ecosystem. In this regard, the present study has been conducted in the aquaculture ponds of East Kolkata Wetlands (the largest 'aquaculture pond regime situated in a wetland' of the world). The main objective of the study was to assess the atmosphere-hydrosphere CO_2 exchange from this wetland system and to identify its effects on the surrounding areas and how the change can be mitigated at a localized level. The study is expected to reveal the consequences of wetlands as a carbon dioxide source on environment and micro-climate of the region and any possible mitigation strategy in order to combat the future effects. As the wetlands also act as an economy generation unit as well, thus it could be sustainably utilized for long-run and possible anthropogenic efforts would be required to turn it into a sink of carbon dioxide.

Study Area - Importance of East Kolkata Wetland

East Kolkata Wetlands (Fig. 1) recognized as a "Wetland of International Importance" is also known as the kidney of the city, setting an example of environmental protection, management and development by adopting a complex ecological process for livelihood generation (Ramsar Convention). The multi-facet services provided by the wetlands include solid-waste and sewer treatment, habitat for migratory waterfowl, rich biodiversity, local employment through waste-fed agriculture and pisciculture, air purification by acting as a carbon sink, mitigation of urban flooding, groundwater recharge, eco-tourism, research and education amongst others (Dhar, 2013). Pisciculture has been given importance in biosequestration, as owing to their high mobility, they are able to create bioturbation and transportation of nutrients from substrates to the upper surface. The fish ponds yield approximately 10,915 million tons of fish annually, resulting in carbon assimilation and sequestration through pisciculture practices (Pal *et al*., 2016). (Pal *et al*., 2016) while studying in this sewage-fed aquaculture system focuses on the amount of nutrient exported from aquatic systems by the fish movement, as it increases the carbon capture efficiency and productivity of the system. The nutrient-rich sewage enhances the net primary productivity of the fish pond, which subsequently increases the biomass of primary consumers (zooplankton) and secondary consumers (fish). This particular study also talks about seasonal carbon sequestration variations in phytoplankton, zooplankton and fish per unit volume of water (Pal *et al*., 2016).

Kolkata's drainage system is a good example of urban planning and utilization of natural resources. The dry weather flow and stormwater flow are an intrinsic part of the city's drainage system and run parallel throughout till discharging into Kulti-Bidyadhari River at Ghusighata. The city is connected with the wetland systems through channels, Storm Water Flow (SWF), which hold the excess water during the monsoon period and Dry Weather Flow (DWF) for sewage water from the city (Niyogi, 2015). The idea of utilizing the wetlands for natural purification of sewage water started with the British's. A series of treatment plants are constructed for treatment of dry weather flow and are channelized to local fields for waste-fed agriculture and aquaculture, where sewage water gets naturally treated. The sewage is retained for a brief period of time in the Bheries/fishponds, which acts as solar reactors and naturally changes the biochemistry of the wastewater. The process of algal photosynthesis effectively cleans the wastewater and removes pathogenic bacteria, which can be used to irrigate paddy fields creating a near-perfect natural recycling system (Dhar, 2013). Presently the treatment plants are not functional and a sustained flow is maintained even in the stormwater flow which should technically be dry the year around, indicating the diversion of water from the Dry Weather flow. And the water level for allowed accumulation and passage to EKW is maintained at 7.5 ft instead of 9ft, which releases untreated water directly to the wetland systems and to Kulti River, thereby deteriorating the marine biodiversity (Niyogi, 2015).

East Kolkata Wetlands is a suitable site for the study, owing to its multi-facet activities. Its contribution to the city's well-being makes it a recommended site for study and its subsequent conservation and protection. The complex is also an economy and livelihood generation site, where numerous small-level businesses is set up utilizing the services of wetlands and their high dependency requires maintenance of the wetland system for future sustenance. The peri-urban wetland has also minimized the effects of coastal hazards, which could have been tremendously disastrous for the city.

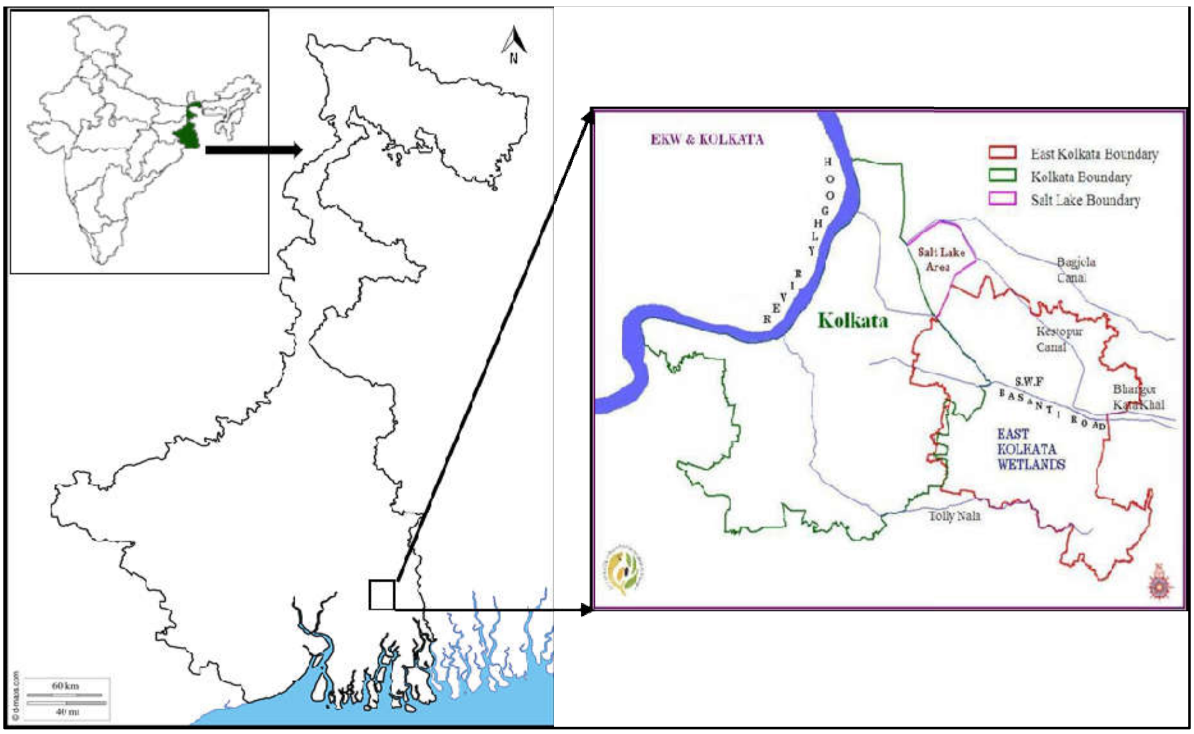

Figure 1 The study area map of East Kolkata Wetlands

METHODOLOGY

Water surface electrical conductivity and water temperature were measured using a Multikit (WTW Multi 340 i Set; Merck, Germany) fitted with the probe WTW Tetracon 325. The precision of electrical conductivity and temperature was 1 µS/cm and 0.1 ºC respectively. Dissolved oxygen (DO) was analysed by means of Winkler's titrimetric method (analytical precision 0.07%). Underwater photosynthetically active radiation (PAR) was measured using standard sensors (UWQ 8247, Li-Cor, USA, precision 0.1 µ mol m^{-2} s^{-1}) and a data logger (Li-250A, Li-Cor, USA). pH was measured with the help of Orion PerpHecT ROSS Combination pH Micro Electrode fitted to a micro-pH meter (data logger) [Thermo Scientific, U.S.A.] with a precision of 0.001. The glass electrodes for pH measurements were calibrated daily on the NBS scale with technical buffers of pH 4.01 (Part no: 1.09475.0500; Merck), pH 7.00 (Part no: 1.09477.0500; Merck) and pH 9.00 (Part no: 1.09476.0500; Merck) at a controlled temperature of 25°C. Water samples were collected carefully with the help of 300 ml BOD bottles and they were poisoned with saturated HgCL2 solution and brought back to laboratory for analysis of total alkalinity (TAlk). TAlk was analysed by using an automated titrator (905 Titrando, Metrohm, Switzerland). The partial pressure of carbon dioxide in water [$p CO_2$ (water)] and dissolved inorganic carbon (DIC) were computed from TAlk and pH using the software CO_2SYS.EXE [*Lewis and Wallace*, 1998]. The dissociation constants K_1 and K_2 are used according to *Millero* (1979) for zero salinity waters on the NBS scale and the correction for sulphate was implied according to *Khoo et al*. (1977). CO_2 concentration in the ambient air was measured with a non-dispersive infrared (NDIR) sensor (Li-840A; Li-COR, USA). The analyzer was calibrated twice daily with a certified reference standard gas of known concentrations of CO_2 in N_2 gas (0, 300 and 600 ppm), procured from Chemtron Science Laboratories, India. The measured mol fraction of CO_2 is converted to partial pressure of air [$p CO_2$ (air)] by using air temperature and pressure, and the virial equation of state [*Weiss*, 1974]. Air temperature, atmospheric pressure and wind velocity were monitored onboard by a Weather Station (WS-2350, La Crosse Technology).

Following MacIntyre *et al*. (2005), the pCO_2(water) and pCO2(air) were converted to concentration of carbon dioxide in water (CO_2wc) and air (CO_2ac) according to the equations (1), (2) and (3).

$$CO_2wc = K_H \times pCO_2(water) \qquad \ldots\ldots\ldots\ldots(1)$$

$$CO_2ac = K_H \times pCO_2(air) \qquad \ldots\ldots\ldots\ldots(2)$$

$$\text{And } \ln K_H = -58.0931 + 90.5069 \times (100/T_K) + 22.294 \times \ln (T_K/100) \qquad \ldots\ldots\ldots\ldots(3)$$

Where K_H is the gas partition constant of CO_2 in water at sampling temperature, expressed in mole L^{-1} atm^{-1}, and T_K is the temperature in Kelvin (Weiss, 1974).

The CO_2 flux is calculated according to equation (4) (MacIntyre *et al*., 1995).

$$\text{Flux } (F_{CO2} \text{ in } \mu mol\ m^{-2}\ h^{-1}) = k_x\,(CO_2wc - CO_2ac) \qquad \ldots\ldots\ldots\ldots(4)$$

Where k_x denotes the mass transfer coefficient (cm h^{-1}) and it is computed according to equation (5)

$$k_x = k_{600} \times (S_c/600)^{-x} \qquad \ldots\ldots\ldots\ldots(5)$$

where Sc is the Schmidt number for CO_2 and it is dependent of water temperature (T, in Kelvin) according to the equation (6). k_{600} is computed from the wind speed (U_{10}), according to Cole and Caraco (1998) (equation 7) and 'x' is equal to 0.66 for wind speed ≤ 3m s^{-1} and is equal to 0.5 for wind speed > 3 m s^{-1}.

$$S_c = 1911.1 - 118.11\times T + 3.4527\times T^2 - 0.04132\times T^3 \qquad \ldots\ldots\ldots\ldots(6)$$

$$k_{600} = 2.07 + (0.215 \times U_{10}^{1.7}) \qquad \ldots\ldots\ldots\ldots(7)$$

RESULTS AND ANALYSIS

Hydrological Settings

Water surface temperature was recorded to be the highest in August, during the monsoon season (34.4 ± 1.2 °C) and minimum in December, during the post-monsoon season (23.3 ± 0.3 °C) (Table 1). Electrical conductivity reached the highest during the month of May in the pre-monsoon season (1520 µS cm^{-1}) and subsequently decreased during the monsoon and post-monsoon (1388 µS cm^{-1} and 854 µS cm^{-1} respectively). It was found to increase during the peak noon hours, irrespective of the seasonal variation. The relationship between increasing temperature and subsequent salinity is prominent from the data. pH measures the acidity and is defined as the negative logarithm of H^+ ion concentration of a solution, the value of which may vary with the excess amount of nutrients or wastewater in the system. Natural waters have a pH in the range of 4-9, with most systems being basic in nature due to the presence of carbonates and bicarbonates of earth metals. pH in the study site ranged between 7 and 8 in all the three seasons studied. The pCO_2(water) was observed to decrease with increasing temperature, in the whole duration of the day. PAR was observed to increase gradually with temperature and peaks at 1000 hours to 1400 hours, then gradually decreased with decreased amount of sunlight. It has also been observed, that PAR followed an inverse relation with the pCO_2(water), which indicates the utilization of available CO_2 in the surface water for photosynthesis. DO is the amount of oxygen present in water for the functioning of organisms and is released as a by-product during the photosynthesis process. Its concentration shows variation under different season, temperature, water depth, pressure and salinity. DO concentration varied inversely with pCO_2(water).

Table 1 The mean ± standard deviation of the atmospheric, physico-chemical and carbonate chemistry parameters during pre-monsoon, monsoon and post-monsoon season

Parameters	Pre-monsoon	Monsoon	Post-monsoon
pH	7.982 ± 0.086	8.129 ± 0.080	8.409 ± 0.037
Conductivity (µS cm^{-1})	1519 ± 69	1387 ± 63	854 ± 21
Water Temperature (°C)	34.4 ± 1.2	34.9 ± 1.0	23.3 ± 0.3
TAlk (µ mol kg^{-1})	2869 ± 105	3252 ± 71	2675 ± 15
DIC (µ mol kg^{-1})	2913 ± 122	3274 ± 86	2666 ± 18
DO (mg l^{-1})	5.95 ± 0.99	9.97 ± 1.37	11.18 ± 1.43
PAR (µ mol m^{-2} s^{-1})	7.99 ± 3.64	4.72 ± 2.48	1.22 ± 0.79
pCO_2 (water) [µ atm]	2288 ± 489	1853 ± 360	658 ± 57
Gas Transfer Velocity (cm h^{-1})	8.3 ± 0.6	7.6 ± 0.4	4.9 ± 0.1
CO_2 Flux (µmol m^{-2} h^{-1})	4183 ± 942	2897 ± 682	437 ± 99

The reason can be attributed to the high photosynthesis rate in the wetland system, with organisms actively participating in the process due to increased temperature and continuously releasing by-product as oxygen.

AIR-WATER CO_2 FLUX

Air-water CO_2 flux varied largely in the three seasonal data, an average of which was 4184 µmol m^{-2} h^{-1}, 2897 µmol m^{-2} h^{-1} and 437 µmol m^{-2} h^{-1} during pre-monsoon, monsoon and post-monsoon respectively. The main reason behind such a source character could be the abundance of organic matter from the municipal wastes driven in these ponds. Though these waters are rich in nutrients and photosynthesis takes place at a higher rate during the day time, the total water column exhibited net heterotrophy. Rapid decomposition of organic matter by the microbial community and immense zooplankton grazing could be the factors responsible behind such high positive fluxes.

PAR was noted to be the highest at 1200 hours (12.24 µmol m^{-2} s^{-1}) which starts to decrease with day fall and absence of sunlight. DO was found to have an inverse relation with pCO_2(water), it gradually increases to a peak of 7.5 mg l^{-1} at 1400 hour, where pCO_2(water) value is noted to be the lowest, that is 1680 µatm also at 1400 hours. Average DO was found to be 6 mg l^{-1}. pCO_2(air) did not vary much with an average of 409 ± 1.9 µatm. CO_2 flux is observed to be increasing with increasing temperature during the first few hours of the day and then during mid-noon, it starts to lower down, with an average of 4184 ± 942 µmol m^{-2} h^{-1}.

In the month of August (monsoon season) also significant diurnal variability is observed. pH is observed to increase with increasing temperature, whereas alkalinity is observed to show a reversing trend that is, decreasing with increasing

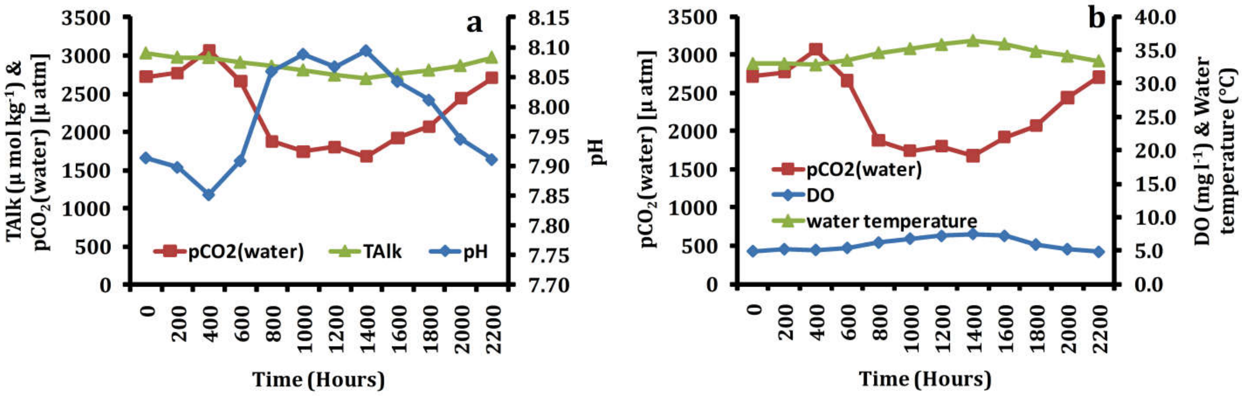

Figure 2 The diurnal variability of pCO_2(water) along with (a) total alkalinity and pH; (b) dissolved oxygen and water temperature during pre-monsoon season

In the month of May, (pre-monsoon season), the flux shows variation with temperature during the whole span of the day. Temperature can be a prominent parameter attributing to the variation in the flux rate as PAR also varies with temperature and so does the photosynthetic potential of the aquatic bodies. pH is observed to increase with increasing temperature, whereas alkalinity is observed to show a reversing trend that is, decreasing with increasing temperature (Figure 2). The average pH and alkalinity were measured to 7.98 and 2869 µmol kg^{-1} respectively. pCO_2(water) and its solubility shows a similar trend and is seen to increase during early hours of sampling, then decreases with increasing temperature with an average of 2289 ± 489 µatm.

The average pH and alkalinity were 8.13 and 3252 µmol kg^{-1} respectively. pCO_2(water) and its solubility shows a similar trend and is seen to increase during early hours of sampling, then decreases with increasing temperature with an average of 1853 ± 360 µ atm (Figure 3). PAR starts to increase from 600 hours and reaches a peak of 7.58 µmol $m^{-2}s^{-1}$ at 1200 hours and then again starts to decrease with diminishing sunlight. DO was found to be gradually increasing with a peak of 12.2 mg l^{-1} at 1200 hours, whereas pCO_2(water) value was the least (1361 µ atm at 1400 hours). Average DO was found to be 10 mg l^{-1}. The average pCO_2(air) was 407.4 ± 2.3 µatm. CO_2 flux is observed to be increasing with increasing temperature during

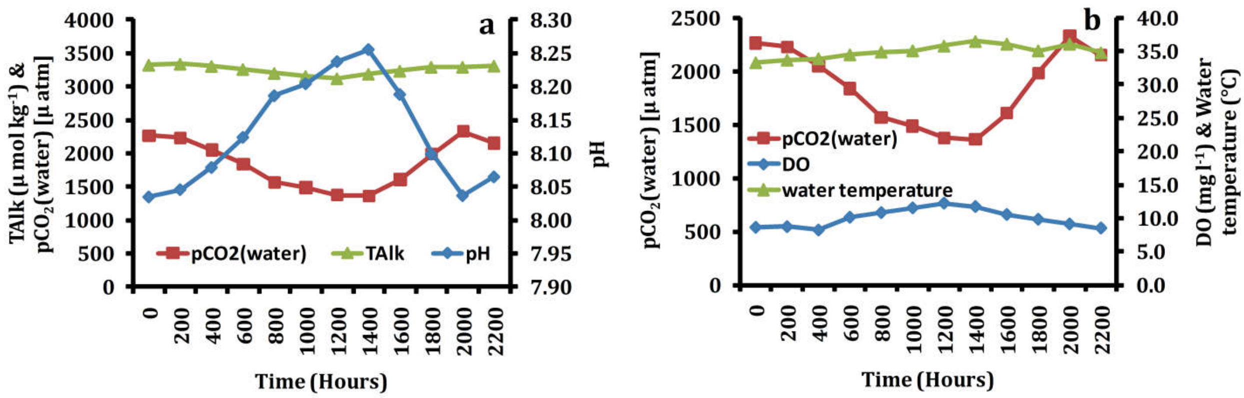

Figure 3 The diurnal variability of pCO_2(water) along with (a) total alkalinity and pH; (b) dissolved oxygen and water temperature during monsoon season

the first few hours of the day and then during mid-noon, it starts to lower down, with an average of 2897 ± 683 µmol m^{-2} h^{-1}.

itself. In the East Kolkata Wetlands, it can be recommended to practice eutrophication in a very controlled manner so as to enhance the photosynthetic carbon assimilation up to an

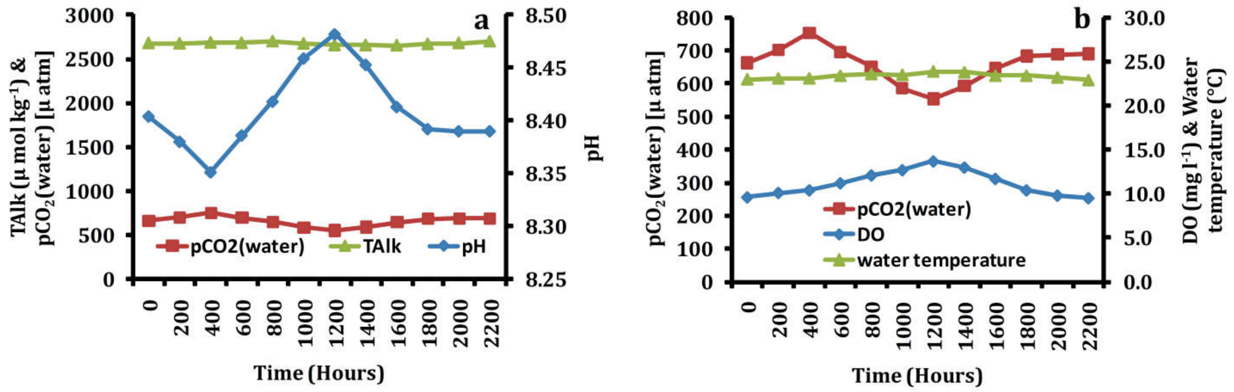

Figure 4 The diurnal variability of pCO_2(water) along with (a) total alkalinity and pH; (b) dissolved oxygen and water temperature during post-monsoon season

Like the other two seasons, diurnal variability of was flux also observed in December (post-monsoon season (Figure 4). pH is observed to increase with increasing temperature, whereas, alkalinity decreased with increasing temperature. The average pH and alkalinity were 8.4 and 2675 µmol kg^{-1}, respectively. pCO_2(water) and its solubility shows a similar trend and is seen to increase during early hours of sampling, then decreases with increasing temperature with an average of 659 ± 57 µatm. pCO_2(water) was found to be the least during this season though the PAR was not so high. This could be attributed to the lower runoff and hence lower organic matter discharge in this wetland system. Average DO was found to be the highest amongst all the seasons (11 mg l^{-1}). The pCO2(air) was almost same like the other seasons (408.7 ± 0.34 µ atm). CO_2 flux (like the other seasons) is observed to be increasing with increasing temperature during the first few hours of the day and then during mid-noon, it starts to lower down, with an average of 438 ± 100 µmol m^{-2} h^{-1}.

DISCUSSION AND CONCLUSION

Analyzing all the results it can be concluded that the aquaculture ponds of East Kolkata Wetland system is acting as a source of carbon dioxide in all three seasons, namely pre-monsoon, monsoon and post-monsoon. Higher air-water CO_2 fluxes were observed during the summer months (pre-monsoon season) followed by monsoon season and the least in post-monsoon season. This indicates that with more increase in temperature in near future, more CO_2 emission is expected to take place, thereby contributing to the change in micro-climate. Untreated wastewater is another crucial factor, which is responsible for CO_2 emissions from wetlands. Control in the production of waste, as well as waste-water treatment of raw sewage which is completely absent at present, can be revived, so that treated water enters the wetland complex, which would be lean in organic matter and hence lesser rate of decomposition could lead to lower magnitude of effluxes of CO_2.

As stated by several authors that eutrophication can be considered as a potential recommendation in a role reversal of lakes/wetlands in global C cycle, though it represents parts of two converging problems, carbon source and eutrophication optimum level without compromising the quality of the entire aquatic ecosystem.

Microorganisms play an important role in carbon turnover in the wetlands that needs to be studied for a better understanding of the effects of climate change on the organisms and their functioning. The fish-feed received from the adjacent tanneries may be detrimental, which are continuously used in the aquaculture ponds for a prolonged period of time. Instead of being an efficient resource-recovery technology, it may have a negative effect on carbon balance. Strategies which involve the different composition of feedstock will be more preferred in the long run.

The fragmented systems require strict management to ensure no further encroachment with a focus on maintenance of natural vegetation or re-vegetation. The plant species (hydrophytes mainly) native to the area and their carbon uptake, storage and release can be extensively studied for their role in carbon flux. The fragmentation has also resulted in a decreased population of native flora and fauna as well as migratory avian population, which raises an alarm to many ecologists.

The wetlands complex can be transformed into a greenbelt area, considering the development of IT sector in the locality, which is also an initiative recommended by USAID-ICMA-CEE-Conservation Plan of EKW.

Wetlands (Conservation and Management) Rules, 2017 is a step towards the betterment of degraded wetlands through decentralization of wetlands management to the respective states which are also in accordance with the 'wise-use" of wetlands as mentioned in Ramsar Convention. The West Bengal Government has been forward in recognizing the importance of wetlands in the state. Urbanization to provide homes to ever increasing population is obviously an urgent need of the hour, however, sustainable management of wetlands should be considered besides optimum urbanization in an around this area to protect such a crucial carbon sink ecosystem.

The study was intended with an expectation of results supporting the role of wetlands as a sink of carbon dioxide, but it showed a role reversal in the study period. Though it was done in a single water body, the same is expected to reflect the status of whole system. The urban wetlands though releasing a mere amount of carbon dioxide may have an immediate or distant after effect on the city's climate. With more development and increase in temperature, the city's temperature will face an increase and thereby strategies to be opted to convert the system again into a sink for CO_2 must be given prior importance. The same assessment study can also be replicated to other satellite wetlands adjacent to East Kolkata Wetlands, which will give rise to the inventory of wetlands as well as their proper maintenance and conservation.

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Reference

Anderson, F., Bergamaschi, B., Sturtevant, C., Knox, S., Hastings, L., Myers, L. and Fujii, R. (2016). Variation of energy and carbon fluxes from a restored temperate freshwater wetland and implications for carbon market verification protocols. *J. Geophys. Res.,* 121(3), 777-795. doi:10.1002/2015JG003083

Australian Government (2012). *The Role of Wetlands in the Carbon Cycle.* Australia: Department of Sustainability, Environment, Water, Population and Communities and Wetlands and Waterbirds Taskforce. Retrieved December 30, 2017, from https://www.environment.gov.au

Balme, M. and Downing, J. (2011). Carbon dioxide concentrations in eutrophic lakes: undersaturation implies atmospheric uptake. *Inland Waters*, 1, 125-132.

Cao, M., Gregson, K., & Marshall, S. (1998). Global methane emission from wetlands and its sensitivity to climate change. *Atmos. Environ.,* 32(19), 3293-3299.

Chanda, A., Akhand, A., Dutta, S. and Hazra, S. (2011). Summer Fluxes of CO_2 from Soil, in the Coastal Margin of World's Largest Mangrove Patch of Sundarbans-First Report. *J. Basic Appl. Sci. Res.,* 1(11), 2137-2141.

Cole, J. J., Caraco, N. F. (1998) Atmospheric exchange of carbon dioxide in a low-wind oligotrophic lake measured by the addition of SF_6. *Limnol. Oceanogr.*, 43, 647–656.

Commonwealth of Australia. (2012). *The Role of Wetlands in the Carbon Cycle.* Australian Government, Department of Sustainability, Environment, Water, Population and Communities. Retrieved January 06, 2017, from https://www.environment.gov.au

Cruz, A. A. (1986). Tropical wetlands as a carbon source. *Aquat Bot*, *25*, 109-115.

Dhar, S. (2013). *Wetlands Transform a City's Sewage Through a Bit of Solar Alchemy.* Retrieved January 18, 2018, from https://nextcity.org/daily/entry/wetlands-turn-a-citys-sewage-into-the-water-that-irrigates-its-crops

Kayranli, B., Scholz, M., Mustafa, A. and Hedmark, Å. (2010). Carbon Storage and Fluxes within Freshwater Wetlands: a Critical Review. *Wetlands, 30*, 111-124.

Khoo, K.H., Ramette, R.W., Culberson C.H., Bates, R. G. (1977) Determination of hydrogen ion concentrations in seawater from 5 to 40°C: standard potentials at salinities from 20 to 45‰, *Anal. Chem.*, *49* (1), 29–34.

Kirschbaum, M. U. (1995). The temperature dependence of soil organic matter decomposition, and the effect of global warming on soil organic C storage. *Soil Biology and Biochemistry, 27*(6), 753-760.

Kundu, S. (2011). *Changing Pattern of Temperature and Rainfall in East Kolkata Wetland.* Retrieved January 17, 2018, from http://shodhganga.inflibnet.ac.in/bitstream/10603/70690/ 10/10_chapter%202.pdf

Lewis, E., Wallace, D.W.R. (1998) Program developed for CO_2 system calculations. ORNL/CDIAC – 105. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee.

MacIntyre, S., Wanninkhof, R., and Chanton, J. P. (1995) Trace gas exchange across the air-water interface in freshwater and costal marine environments, in: (eds, Matson, P. A., Harriss, R. C.) Biogenic trace gases: Measuring emissions from soil and water, Blackwell Science, Oxford, 52–97.

Maynard, S., Davidson, A., James, D., Mooney, S., Petter, M., McPherson, D., & Walker, M. (2017). *The SEQ Ecosystem Services Framework*. Retrieved February 16, 2018, from http://www.ecosystemservicesseq.com.au/ step-1-reporting-categories/lacustrine-wetlands

McDermott, M. (2009). *Mangrove and coastal wetlands store 50 times more carbon than tropical by area.* Retrieved January 17, 2018, from https://www.treehugger.com/ natural-sciences/mangroves-coastal- wetlands-store-50-times-more-carbon-than-tropical-forests-by-area.html

Millero, F.J. (1979) Thermodynamics of the carbon dioxide system in the oceans. Geochimica et Cosmochimica Acta, 59(4), 661-677

Ministry of Environment, Forest and Climate Change. (2018). *Ramsar Convention on Wetlands*. Retrieved January 17, 2018, from http://www.moef.nic.in/division/ ramsar-convention-wetland

NCSU Water Quality Group. (2017). *FUNCTIONS OF WETLANDS (Processes).* Retrieved December 30, 2017, from WATERSHEDSS: http://www.water.ncsu.edu/ watershedss/info/ wetlands/function.html

Niyogi, S. (2015). Man-made sewage crisis spells doom for Kolkata wetlands. *The Times of India City*. Retrieved January 18, 2018, from https://timesofindia.indiatimes.com/city/ kolkata /Man-made-sewage-crisis-spells-doom-for-Kolkata-wetlands/articleshow/46137442.cms

Pacheco, F., Roland, F. and Downing, J. (2013). Eutrophication reverses whole-lake carbon budgets. *Inland waters, 4*, 41-48.

Pal, S., Chattopadhyay, B., and Mukhopadhyay, S. K. (2016). Spatio-temporal study of carbon sequestration through piscicultural practice at East Kolkata Wetland. *J. Environ. Biol., 37*(5), 965-971.

Pant, H. K., Rechcigl, J. E., & Adjei, M. B. (2003). Carbon sequestration in wetlands: Concept and estimation. *Food, Agricult. Environ., 1*(2), 308-313.

Perceval, C. (2014). Role of wetlands in carbon storage and sequestration. Bonn: UNFCCC TEM. Retrieved January 18, 2018, from https://unfccc.int/files/bodies/awg/application/pdf/ ramsar _perceval_intervention.pdf

Ramsar Convention on Wetlands. (n.d.). *Flood Control.* Gland: Ramsar Convention on Wetlands. Retrieved December 30, 2017, from Wetland Ecosystem Services: http://archive.ramsar.org/pdf/info/services_01_e.pdf

Scholz, M. (2011). Are Wetlands Carbon Sources or Sinks? In M. Scholz (Ed.), *Wetland Systems: Storn water Management Control* (p. 234). United Kingdom: Springer. Retrieved from http://www.springer.com/in/book/9781849964586

Singh, M. N. (2016). *Wetlands: Source or sinks of Greenhouse Gases.* Retrieved February 16, 2018, from http://www.iitk.ac.in/nerd/web/articles/wetlands-sources-or-sinks-of-greenhouse-gases/#.WoZ2iKiWbIU

Tang, X.-L., Zhou, G.-Y., Liu, S.-G., Zhang, D.-Q., Liu, S.-Z., Li, J., and Zhou, C.-Y. (2006). Dependence of Soil Respiration on Soil Temperature and Soil Moisture in Successional Forests in Southern China. *J. Integrat. Plant Biol., 48*(6), 654-663.

University of Guelph. (2014). *Wetlands are likely to blame for atmospheric increase: Study.* Retrieved January 18, 2018, from https://www.sciencedaily.com/releases/2014/04/ 140428121353.htm

Weiss, R.F. (1974) Carbon dioxide in water and seawater: the solubility of non-ideal gas. *Mar. Chem.*, *2*, 203–215.

Whalen, S. C. (2005). Biochemistry of Methane Exchange between Natural wetlands and the Atmosphere. *Environ. Eng. Sci., 22*(1), 73-94.

Whiting, G. J., and Chanton, J. P. (2001). Greenhouse carbon balance of wetlands: methane emission versus carbon sequestration. *Tellus B, 53*(5), 521-528.

WWF Global. (2017). *The wonder of wetlands.* Retrieved Decemeber 30, 2017, from WWF Global: http://wwf.panda.org/about_our_earth/about_freshwater/intro/

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