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Carbon dioxide system and its impact on pH and alkalinity in the wetlands of northern India, Aligarh region

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Abstract
Aligarh one of the famous places of Utter Pradesh (U.P) India is richly well-off with wetlands. They support an extensive and regular fishery of various kinds. The carbon dioxide system contributes the fitness of the wetlands, as it serves to buffer the environment against rapid changes in *pH* and also regulates biological processes in aquatic communities. Free CO_2 was never found to be present in these wetlands of Aligarh region of northern India. Its absence in all the samples may be attributed to increased *pH* values. It may be also due to its complete utilization during photosynthesis by green aquatic organisms. *Alkalinity*, which is important for aquatic life, was found to be contributed mainly by *Calcium* and *Magnesium* cations forming *carbonates*, *bicarbonates*, *hydroxide* ions. *Carbonates* were recorded in all the samples collected from these wetlands, whereas *bicarbonates* were found to be absent in some samples collected from MP wetland where they are represented by *hydroxide* ions.

Keywords: wetlands, pH, alkalinity

Introduction
Aligarh and its adjoining areas of northern India are richly well-off with wetlands which support an extensive and regular fishery of various kinds. They are surrounded by two river systems, *Ganga* and *Jumuna* with their many tributaries. Wetland of northern India experiences the tropical monsoon type of climate with marked northeast and southwest monsoon.

Natural water bodies load a great variety of gases dissolved in them. Out of these gases, Carbon dioxide (CO_2) is one, of the most significant in smooth regulation of metabolic processes in the organisms (Untoo *et al*. 2001) [8]. Carbon dioxide is important substance in the life of plants and micro-organisms. Its presence gives an opportunity to green macro and microphytes including phytoplankton to synthesis their food and produces oxygen, which is basic need of all animals and plants. On the other hand, large amount of CO_2 in the ecosystem is harmful to life. The CO_2 in aquatic ecosystem is found in two forms, in *free gas form* and in *combination* with other substances. The free CO_2 contributes to the fitness of natural waters as it serves to buffer the environment against rapid changes in the pH and also regulates biological processes in aquatic communities to form many compounds. There are many sources of CO_2 in the wetlands. They include atmospheric CO_2, respiration by the organisms and bacterial decomposition of organic matter etc. (Kaushik and Saksena, 1999) [12]. The presence or absence of free CO_2 in the surface waters is mostly governed by its utilization by algae during photosynthesis and also through its diffusion from air (Sreenivasan, 1972, 1974). Thus, free CO_2 may be present throughout the study period. (Ganapati 1956; Verma, 1969; Chourasia and Adoni, 1985; Singhal *et al*., 1986) [6, 4, 26] or in some samples taken in few successive months of study period (Verema and Shukla, 1986; Qadri and Yousuf, 1978) [23] or may be absent altogether (Gaur *et al*., 2001). Lot of work has been done on carbon dioxide by many workers in both temperate and tropical wetlands. Khan and Siddiqui, 1974; Khan *et al*., (1999, 2002, 2003) [15, 14, 16, 17]; Singhal *et al*., 1986; Hosetti, 2002; Vajaykumar, 1999; Parveen *et al.*, (2010) [26, 10, 21]. Untoo *et al.*, (2001) [8] has reported complete absence of CO_2 in tropical wetlands in some seasons. The absence of CO_2 is mainly due to its complete utilization during photosynthesis by algae or carbonates present did not allow the CO_2 to produce in the bottom and column to reach to the surface (Ganapati, 1960). In the present investigation of these wetlands of Aligarh region of northern India, it was found that CO_2 was totally absent in all the samples collected during the investigations but *Carbonates* were recorded in all the samples and *bicarbonates* in few samples which were replaced by *hydroxide* ions collected from these wetlands.

pH of water is considered to be one of the most important chemical factors affecting the productivity of any wetland. It has direct effect on fish and fisheries as well as on the growth and survival of other aquatic organisms. PH is a term used rather universally *to express the intensity of the acid or alkaline condition of a system*. The variations in pH are linked with the chemical changes, species composition and life processes of animal and plant communities inhabiting the system. Maintenance of a constant pH in the body fluid at a given temperature is one of the important tasks of the regulatory system for homoeostasis in aquatic animals (Alabaster and Lloyd, 1984). Hence, to achieve good fish production, pH of water should be monitored regularly to ensure optimum range. Webber and Stumm (1963) [33] have

concluded that the pH of the raw water sources mostly lies within the range between 6.5- 8.5. All inland waters and wetlands in India lie in the alkaline range without much variation (Sreenivasan, 1972; Singhal *et al*., 1986, Gosh and George, 1989; Singhal *et al*., 1986; Khan *et al*.,2002; Gaur *et al*., 2001; Parveen *et al.,* (2010) [26, 10, 21]; Parveen & Untoo (2014) and Untoo *et al.,* (2001) [8].

Alkalinity of *the water is a measure of its capacity to neutralize acid*. The alkalinity, in natural waters, is mainly caused by three major classes of materials which may be ranked in order of their association with high pH values. The role of alkalinity in the determination of the productive capacity of an aquatic environment has also been described by Phillipose (1959) [19]. He categorized inland waters into three types namely, *soft*, *medium* and *hard* waters. According to him, water with low alkalinity was comparatively less productive than the water with high alkalinity.

Materials and Methods

Aligarh experiences winter season (*December* to *February*), summer season (*March* to *June*), monsoons (*July* to *September*) and post-monsoon (*October* to *November*). In the present investigation three wetlands have been selected to study their Carbon Dioxide System, pH and Alkalinity namely Chharat Pond-1 (CP-1), Chharat Pond-2 (CP-2) and Medical Pond (MP). Since the investigating wetlands were distributed within the radius of 3 to 8 Kms, collection of water samples for the study of *Carbon Dioxide*, *pH* and *Alkalinity*, was done from the surface waters of wetlands between 7:00 am to 9:00 am at regular intervals during August 2014 to December, 2015 in all the four seasons. CO_2 was determined by titrating 100ml of water sample with *N/44 NaOH* (*sodium hydroxide*) solution using *phenolphthalein* as an indicator at the site itself during the course of study.

Analysis of the samples for Alkalinity was made on the site of collection following procedure, precautions and technique given by (A.P.H.A., 1992) [2]. Duplicate samples were taken for each analysis. pH was determined with the help of Marconi's pen type digital pH-Meter.

Results and Discussion

Free CO_2 was found to be absent in all the three wetlands of Aligarh region of northern India during the study. The seasonal variations in the concentrations of total alkalinity and pH are given in the (Table 1) and illustrated in (Figures 1-2).

The monthly values of alkalinity in terms of *carbonate*, *bicarbonate* and *hydroxide* alkalinity showed wide fluctuations in all the three wetlands of Aligarh region of northern India. In CP-1 and CP-2, only carbonate and bicarbonate alkalinities were found, whereas in MP, carbonate, bicarbonate and hydroxide alkalinities were found during the course of study (Table 1).

The monthly values of carbonate alkalinity, at CP-1 and CP-2, were found to vary from 32.0mg/L (February, 2015) to 76.0 mg/L (May, 2015) and 26.0 mg/L (February, 2015) to 84.0 mg/L (May, 2015) respectively (Table 1), whereas in MP, minimum of carbonate alkalinity was found in the month of January, 2015 (36.0mg/L) and maximum during December, 2014 (186.0 mg/L). Bicarbonates varied from 119.0 to 196.0 mg/L in CP-1 and from 115.0 to 182.0 mg/L in CP-2. At CP-1, minimum concentration was recorded during August, 2014 and maximum during July, 2015, whereas in CP-2, minimum concentration was recorded during March, 2015 and maximum during July, 2015. At MP the values of bicarbonates showed variations from 80.0mg/L (August, 2015) to 28.0mg/L (February, 2015), but it was found to be totally absent in some samples collected during post-monsoon and winter months of 2014 and summer and post-monsoon months of 2015. In the absence of bicarbonates in MP, hydroxide alkalinity values showed maximum concentrations (116.0 mg/L) in the months of November, 2015 and minimum (18.0 mg/L) during June, 2015 (Table 1). Similarly, the pH values of the surface waters varied from 8.4 to 9.2 in CP-1 and 8.4 to 9.1 in CP-2, whereas in case of MP it showed variations from 8.3 to 9.2 (Table 1). All the three wetlands thus, showed the alkaline nature of water (Fig. 1 &2).

In the present investigations, free CO_2 was found to be totally absent in all the samples from three wetlands of Aligarh region of northern India. Absence of free CO_2 in all the samples taken may be attributed to increased values of pH (8.4 or above). Similar observations have been reported by Jhingran (1991) [11] and many others (Kaushik and Saksena, 1999) [12]. They have also reported low values of free CO_2 when aquatic vegetation was more abundant. Ganapati (1960) [7] has reported total absence of free CO_2 due to its complete utilization during photosynthesis by algae or carbonates present did not allow the CO_2 to be produced in the bottom and column to reach to the surface. Natural tropical water bodies and wetlands usually show a wide range of fluctuation in total alkalinity values depending upon the location, season, micro and macrophytes populations, rainfall, washermen's activities and nature of bottom deposition etc. Kaushik and Saksena (1999) [12]; Parveen and Untoo (2013) [22]. Alkalinity is important for aquatic life in freshwater ecosystem because it equilibrated pH changes that occur naturally as a result of photosynthetic activity of chlorophyll bearing vegetation. Carbonates, bicarbonates and hydroxide form the basic components of alkalinity in the wetlands of Aligarh region of northern India under study. The chemical buffering of the system is brought about by carbon dioxide-bicarbonate-carbonate complex. This system actually forms the carbon sources of phytoplankton during carbon assimilation. In these wetlands of Aligarh region, the alkalinity was found to be due to mainly calcium and magnesium cations and from either carbonates, bicarbonates or hydroxides (Table1).

In the present study of wetlands of Aligarh, carbonate alkalinity, was recorded in all the samples (Table 1). Kaushik *et al.,* (1999) [12] and Untoo *et al.,* (2001) [8] have reported similar observations with regard to seasonal variations in carbonate alkalinity. During photosynthesis, bicarbonates are broken and carbonates are released (Welch, 1952) [34]. Thus, it is obvious that the changes in the phytoplankton number must be directly related to changes in carbonate concentration. However, no significant direct relationship was obtained between carbonates and phytoplankton in the present study of wetlands of Aligarh region of northern India (Fig. 1).

Bicarbonate alkalinity is the main constituent to the total alkalinity and is invariably present in waters in which photosynthesis is actively taking place (Chourasia and Adoni, 1985) [4]. In the present investigations, it was found to

decrease in certain months of post-monsoon, winter season and increase during summer and monsoon months (Table 1). Very different results have been reported by Chourasia and Adoni (1985) [4], Kaushik *et al*., (1991) [13]. Further, increased bicarbonate values during winter season and decreased values during summer and monsoon months have been reported by Qadri and Yousf (1978) [23]. All these reports showed a bimodal pattern, but, in present study, only one peak of high magnitude appeared in summer that continued in monsoon months (Table 1 & Fig. 1). The increase or decrease in bicarbonate content may be ascribed to the photosynthetic or respiratory activity of the algae respectively.

Ghosh and George (1989) [9] and Parveen *et al*., (2010) [21] have reported that wetlands with a pH range of 7.0 to 9.0 always show a very high bicarbonate concentration. In the present investigations, similar situation have been observed in CP-1 and CP-2. In case of MP, the bicarbonate alkalinity was found to be absent in certain months of the study and instead hydroxide (OH) alkalinity was found to be absent in certain months (Table 1). This condition appears only when the phenolphthalein alkalinity (CO_3) is found greater than the half of the total alkalinity or twice the methyl orange alkalinity (Theroux *et al*., 1943) [30]. In all the three wetlands of Aligarh region of northern India, carbonate alkalinity increased and decreased along with pH of water, being highest when photosynthesis was most pronounced and lowest when photosynthetic process was less active.

In the present study, it was interesting to note that pH values were always found to be 8.4 or more throughout the study period (Table 1). It is well known that changes in pH of water bring about changes in the structural and functional variations in the organisms of the water body. A measurement of hydrogen-ion-concentration is important mean of understanding the nature of chemical conditions, which prevail in the aquatic ecosystem (Welch, 1952) [34]. It was observed that the pH values of CP-1 and CP-2 followed a specific seasonal trend from August to December, 2014 then showed fluctuations during remaining period of study. According to the classification given by Venkateshwarlu (1983), these wetlands of Aligarh can be placed under *Alkaliphilous* (pH range from 7.5 to 9.0) and *Alkalibiontic* (pH range above 9.0). Lowered pH values at CP-1 and CP-2, during monsoon months having cloud covers and during post-monsoon months with decreased photoperiods, were found to be controlled by the decreased photosynthetic activity. Contrary to CP-1 and CP-2, MP wetland showed highest values during monsoon and post- monsoon months of 2014 and post-monsoon months of 2015, low during March and August, 2015 (Table 1).

A fall in pH during monsoon months was also recorded by Kaushik *et al*., (1989, 1991). Also the cloudy atmosphere reduces the pH considerably. Ellis (1937) [5] and Swingle (1967) [29] have suggested that waters with hydrogen ion concentrations ranging between (6.5 to 9.0) are most suitable for fish production. Verma and Shukla (1968) believed thatalkaline waters support large amount of biota. Bell (1971) [3] has stated that pH of 6.5 to 9.0 appears to provide adequate protection to the life of freshwater fish and bottom dwelling fish food organisms. In waters having low pH values, fishes and other aquatic organisms get prone to attacks of parasites and diseases. Ohle (1938) [18] opined that pH above 10 and below 4.8 have a detrimental effect. According to Swingle (1967) [29], if waters have pH less than 6.5 or above 9.5 for a prolonged period, reproduction and growth of fish would diminish. As pH increases above 8.3, there will be absence of CO_2 which is required for the growth of phytoplankton (Theroux *et.al*., 1943) [30]. Spence (1967) [27] has stated that alkalinity and pH are closely connected with an accurate measure of trophic status of lake water. On the basis of Spence (1967) [27] assumption, all the three wetlands of Aligarh of northern India are in increasing order of eutrophic nature. The decrease in pH values during different months was probably due to release of anaerobic water affected by decomposition of concentrated organic matter and the respiration of biota, which increases in pH values was mainly due to rise in carbonate alkalinity, resulting from photosynthetic activity of the phytoplankton and other green aquatic plants. Sreenivasan (1964) [28] has also given the similar reasons.

Table 1: Monthly Variations in pH, Carbonate (CO_3), Bicarbonate (HCO_3) and Hydroxide (OH) in Wetlands of Aligarh, Northern India CP-1: Chharat Pond 1, CP-2: Chharat Pond 2 and MP: Medical Pond

Months↓ Wetlands→	pH			Carbonate (CO_3)			Bicarbonate (HCO_3)			Hydroxide (OH)		
	CP-1	CP-2	MP	CP-1	CP-2	MP	CP-1	CP-2	MP	CP-1	CP-2	MP
August,2014	8.4	8.6	9.2	52.0	56.0	120.0	119.0	126.0	40.0	0.0	0.0	0.0
September,2014	8.4	8.6	9.1	48.0	54.0	88.0	133.0	132.0	62.0	0.0	0.0	0.0
October,2014	8.4	8.6	8.8	48.0	52.0	104.0	131.0	134.0	0.0	0.0	0.0	33.0
November,2014	8.4	8.4	8.8	54.0	40.0	114.0	137.0	137.0	0.0	0.0	0.0	30.0
December,2014	8.5	8.4	8.9	37.0	36.0	186.0	143.0	129.0	0.0	0.0	0.0	40.0
January,2015	9.1	9.0	8.8	39.0	46.0	36.0	132.0	151.0	60.0	0.0	0.0	0.0
February,2015	9.0	8.9	8.7	32.0	26.0	66.0	139.0	127.0	28.0	0.0	0.0	0.0
March,2015	8.7	8.6	8.4	54.0	49.0	90.0	138.0	115.0	0.0	0.0	0.0	30.0
April, 2015	8.7	8.8	8.7	52.0	50.0	96.0	147.0	142.0	0.0	0.0	0.0	36.0
May,2015	9.2	8.9	8.6	76.0	84.0	76.0	171.0	174.0	0.0	0.0	0.0	40.0
June,2015	9.1	9.1	8.7	71.0	64.0	122.0	168.0	178.0	0.0	0.0	0.0	18.0
July,2015	9.1	9.1	8.9	40.0	38.0	100.0	196.0	182.0	0.0	0.0	0.0	37.0
August,2015	9.1	9.1	8.3	48.0	40.0	130.0	149.0	146.0	80.0	0.0	0.0	0.0
September,2015	8.4	8.5	9.3	44.0	37.0	180.0	148.0	151.0	61.0	0.0	0.0	0.0
October,2015	8.4	8.5	9.1	47.0	50.0	120.0	134.0	138.0	0.0	0.0	0.0	90.0
November,2015	8.4	8.4	8.8	56.0	42.0	178.0	140.0	140.0	0.0	0.0	0.0	116.0
December,2015	8.6	8.8	8.6	39.0	43.0	126.0	146.0	139.0	0.0	0.0	0.0	80.0

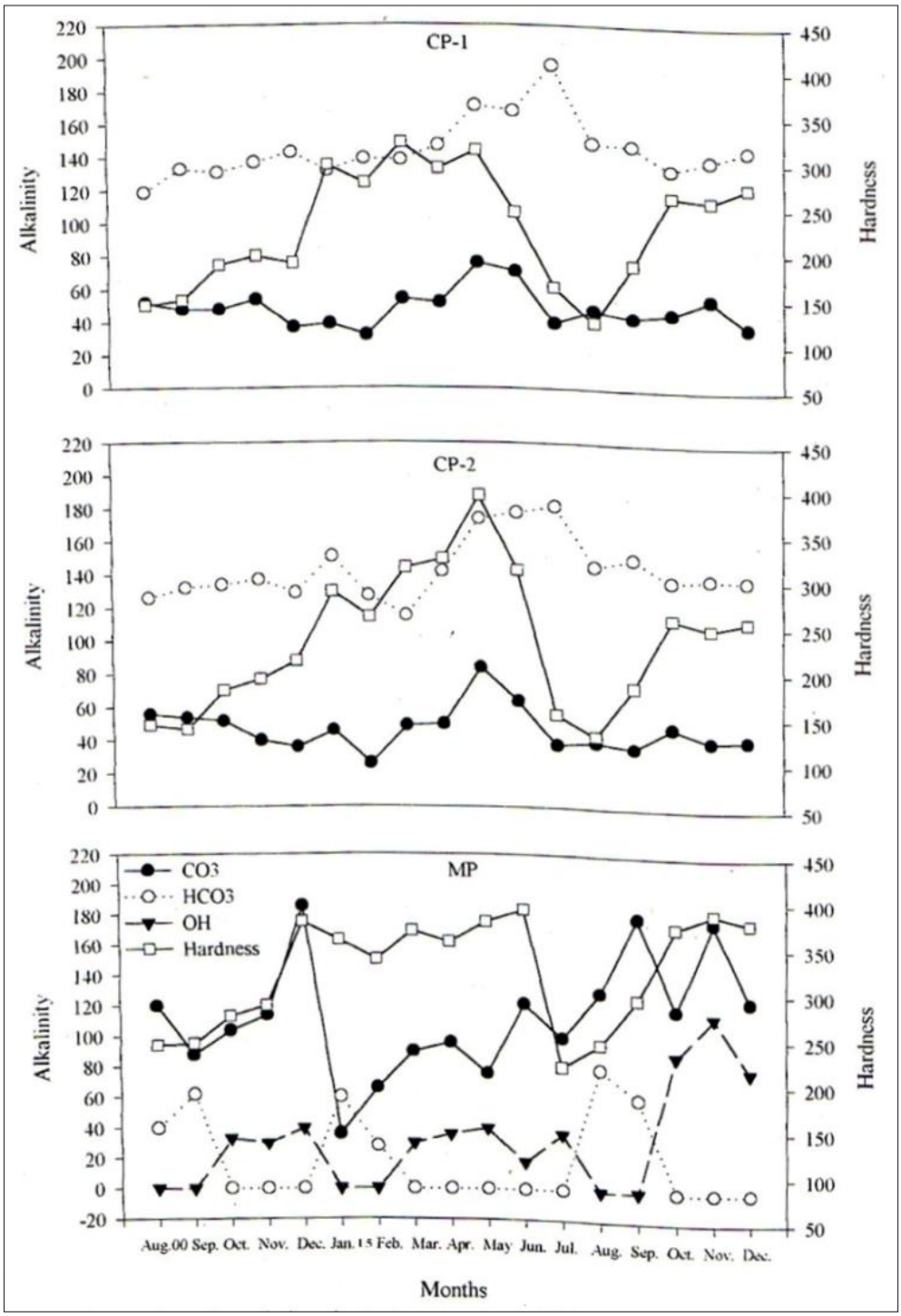

Fig 1: Monthly variations in CO3, HCO3, oh, alkalinity (mg/l) at CP-1 CP-2 and MP wetlands.

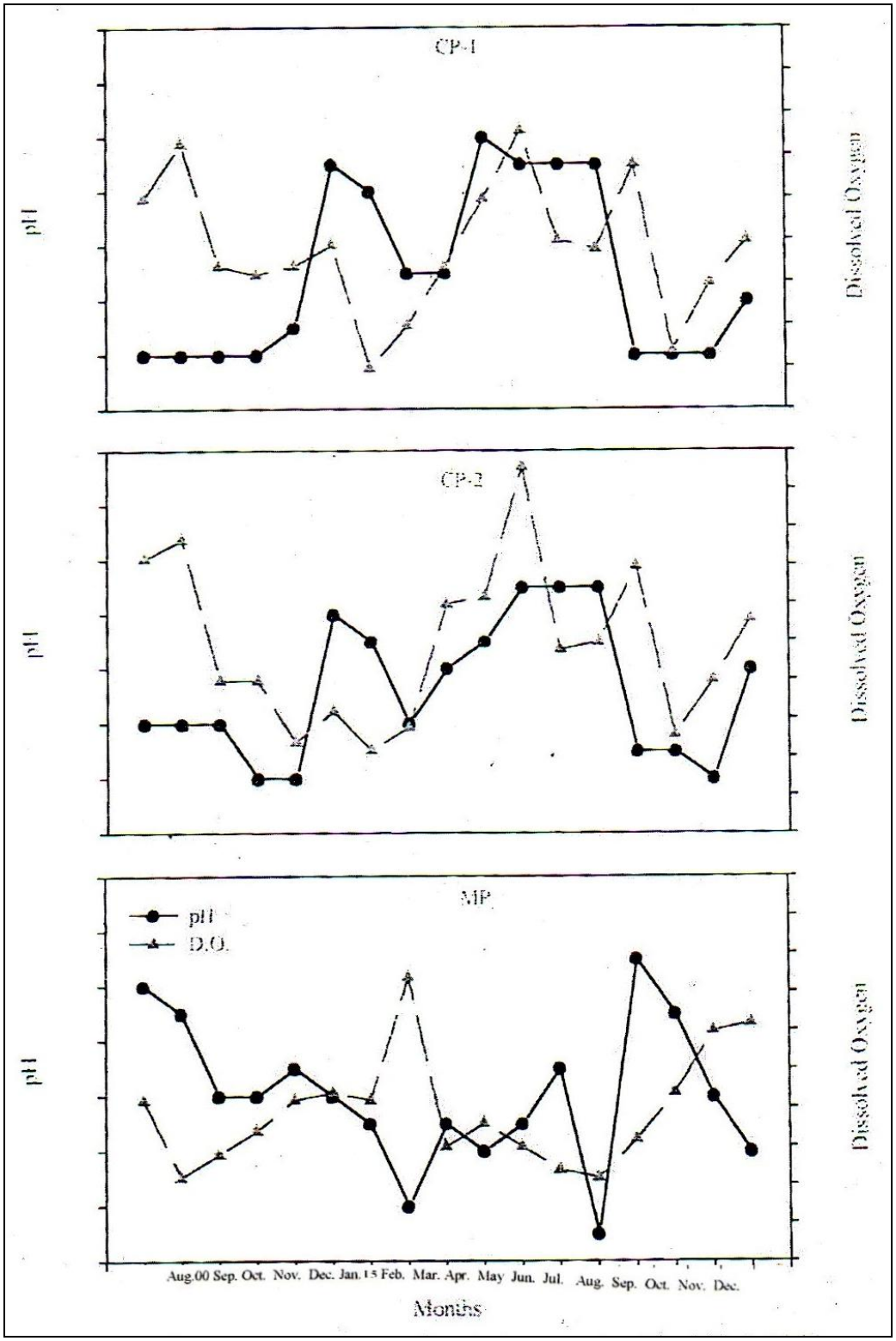

Fig 2: Monthly variations in ph and Disssolved oxyzgen (mg/l) at CP-1, CP-2 and MP Wethland

Conclusion

Free CO_2 which contributes the fitness of the natural waters and it serves as buffer to the environment against rapid changes in pH and also regulates biological processes in aquatic communities, was never found in these three wetlands of Aligarh region of northern India. Its absence in all the samples may be attributed to increased pH values as has been reported by many workers. It may be also due to its complete utilization during photosynthesis by green aquatic organisms. Alkalinity, which is important for aquatic life was found to be contributed mainly by *Ca* and *Mg* cations forming *carbonate*, *bicarbonate* and *hydroxide* ions. *Carbonate* ions were recorded in all the samples collected from these wetlands, whereas *bicarbonates* were found to be absent in some

samples collected from MP wetland where they are represented by *hydroxyl* ions. Further, pH values were found to be always above 8.4 or more throughout the study in these wetlands. These wetlands can be placed under the category of *Alkaliphilous* or *Alkalibiontic*. The decrease in pH values during different months was found to be probably due to release of anaerobic waters affected by decomposition of concentrated organic matter and the respiration of biota, while increase in pH was mainly due to rise in carbonate alkalinity resulting from photosynthetic activity of phytoplankton and other green plants.

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