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SURFACE WATER QUALITY ASSESSMENT AND CONSERVATION MEASURES OF TWO POND ECOSYSTEMS OF CENTRAL GUJARAT

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ABSTRACT:

Wetland is the land area that is saturated with water, either permanently or seasonally such that it takes on the characteristics of a distinct aquatic ecosystem. The present paper highlights the preliminary investigation of physio-chemical characteristics of two pond ecosystems *viz*. ADIT campus pond and Gana village pond in and around satellite township (New Vallabh Vidyanagar), Anand District, Central Gujarat, India. The existing water bodies are contaminated with domestic sewage as well as industrial effluents due to different types of anthropogenic interventions. The research focuses on the seasonal variation of various physico-chemical parameters such as Phenolphthalein Alkalinity (PA), Total Alkalinity (TA), Carbonates (CO_3^-), Bicarbonates (HCO_3^-), Total Hardness (TH), Calcium Hardness (Ca), and Magnesium Hardness (Mg). The present study was carried out for the period of one year by sampling of surface water samples on monthly basis. Analyzed data depicted the higher values of studied parameters during summer and lower contents during winter. The studied ponds were found to be in a eutrophic condition. Moreover, the results obtained manifested the need and urgency to restore the physical, chemical and biological integrity with viable and stringent restoration and management tactics in order to maintain, preserve, conserve and to prevent ecological imbalance and disturbance in hydro-geo-chemical and hydro-biological cycles which ultimately adversely affect the food chain and food web of the significant anthropogenic pond ecosystems.

KEY WORD: *Pond ecosystems, ADIT campus pond, Gana village pond, Surface water, Physico-chemical parameters, seasonal variations, conservation measures.*

INTRODUCTION:

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water **(Cowardin *et al.*, 1979)**. The freshwater ecosystem covers only 0.2% of the total earth's surface area with the volume of 2.04x105 km^3, despite of which these lentic ecosystem supports a variety of endangered and exotic species which contributes to aesthetic and environmental quality in every state **(Lieth, 1975)**. The importance of wetlands cannot be overestimated as they aid in taming floods, keep river flowing in mid-summer, restore water to underground reservoirs, and hold the water table to the appropriate level. But the very existence of these wetlands is under threat due to various developmental activities and human population pressure **(National Wetland Atlas, 2010).** Wetlands are increasingly at risk from tremendous human intervention and alteration of the landscapes. Various types of site-specific activities like dredging, filling, ploughing, ditching, draining as well as anthropogenic activities surrounding the catchment areas leads to degradation, devastation by altering numerous hydrological functions, increasing nutrients and sediment load, and spread of invasive and exotic species **(Linda, 2009; Environment and Heritage, 2013)**. Over the time, wetlands have been exploited to the extent that less than half of the wetlands acreage remains **(Dahl, 1990)**. Freshwater wetlands are ecosystem that is affected by temporary or permanent inundation and are considered as one of the most important resources for the survival of all the living organisms of the biosphere **(Singh *et al.*, 2010)**.

The present research paper is a baseline study of two lentic ecosystems of Central Gujarat, India, which denotes the current scenario of two particular pond ecosystems *viz*. ADIT campus pond and Gana village pond situated in the vicinity of newly-constructed educational township (New Vallabh Vidyanagar), Anand District, Central Gujarat. As per first inventory report, Gujarat has the highest extent of wetlands (17.65%) **(ISRO National Inventory, 2011)**. Stagnant water bodies usually have more complex and fragile ecosystems in comparison to running water bodies as they lack self cleaning ability, thus accumulating greater quantities of pollutants. Increased human interventions in the form of various anthropogenic activities in and around the water bodies damage the aquatic ecosystems and ultimately alter the hydro-chemical properties of water, indirectly leading to huge influx of nutrients and causing harm to the prevailing aquatic biodiversity **(Sidnei *et al.*, 1992)**.

MATERIALS AND METHODS:

STUDY AREA

***ADIT Campus Pond* (ACP)**

ADIT Campus Pond (ACP) **(**22^0 31’ 21^0 34’ N Latitude and 72^0 55’ 07^0 61’ E Longitude) is one of the man-made (constructed) aquatic bodies used for drinking and domestic purposes, as well as disposal of anthropogenic wastes comprises of solid, liquid, semi-solid and colloidal sewage, which is a permanent disposal sites of anthropogenic origin including dumping yard of garbage upto little extent **(Figure 1).**

Figure 1. ADIT Campus Pond (ACP) (Satellite Image)

***Gana Village Pond* (GVP)**

Gana Village Pond (GVP) (22^0 30’28^0 02’ N Latitude and 72^0 54’ 52^0 63’ E Longitude) is one of the man-made (constructed) aquatic bodies, used for only domestic purposes and disposal of anthropogenic wastes comprises of solid, liquid, semi-solid and colloidal sewage, which is a temporary disposal site of anthropogenic origin including dumping yard of garbage upto little extent. GVP is administered by Gana Gram Panchayat (GGP) for the last many years; situated on the outskirts of Gana Village on its western side; spans an approximate area of 800 sq m to 1000 sq m. The hydro-geological regime of GVP is about 20 to 25 feet deep. The physico-chemical characteristics of water and sediments, as well as native aquatic biota (flora) of GVP provide roosting, feeding, foraging, nesting and breeding grounds to the aquatic birds too. Besides, the prevailing open scrub patches interspersed with *Acacia* tree has been proved to be a boon for terrestrial birds including resident, resident migrants as well as migratory birds from different provinces of Gujarat, India and European countries. The hydric regions of the area also support considerable number of aquatic macrophytes, and many more species of Pisces, Amphibians and Reptiles **(Figure 2).**

Figure 2. Gana Village Pond (GVP) (Satellite Image)

SURFACE WATER SAMPLING

After the overall site inspection and vigilant observation, surface water samples were collected randomly from both the study areas on monthly interval for a year (January to December 2010). Collected surface water samples were filtered using 0.45 micron Millipore filter, and were brought to the laboratory in pre-cleaned two liter plastic bottles and preserved with precautions for further analyses **(Maiti, 2003; Gupta, 2004)**. The further analyses were carried out in laboratories by performing various physico-chemical parameters such as Phenolphthalein Alkalinity (PA), Total Alkalinity (TA), Carbonates (CO_3^-), Bicarbonates (HCO_3^-), Total Hardness (TH), Calcium Hardness (Ca), and Magnesium Hardness (Mg) following standard protocol **(APHA, 2004)**.

RESULTS AND DISCUSSION:

SITE-SPECIFIC APPROACH

Phenolphthalein Alkalinity (PA)

Alkalinity represents the buffering capacity for water and its ability to resist a change in pH and is the total measure of the substance in water that has “acid-neutralizing ability”. Excessive alkalinity may cause eye irritation in humans and chlorosis in plants **(Sandhya *et al*., 2012)**. Surface water with alkalinity less than 200 mg/L is potentially sensitive to heavy acid deposition. Alkalinity itself is not harmful to human beings; still water supplies with less than 100 mg^{-l} of alkalinity are desirable for domestic use. The desirable level of total alkalinity for drinking water should be below 200 ppm **(ISI, 1991).** Phenolphthalein is an indicator that changes from pink to colorless at pH 8.3 when acid is added (pH decreases). Water has a pH greater than 8.3 is said to have ‘phenolphthalein alkalinity’” which is primarily due to the presence of carbonate or hydroxide ions.

During the present investigation, wide range of fluctuations in PA content was observed (30 to 210 mg/L) in surface water of Gana Village Pond (GVP). The minimum content was observed in the month of July (30 mg/L) and the maximum amount in the month of December (210 mg/L), whereas in case of ADIT Campus Pond (ACP), the PA content was found to be ranged from 20 to 270 mg/L, with minimum amount in August (20 mg/L) and maximum content in January (270 mg/L) **(Tables 1, 2)**.

Total Alkalinity (TA)

Ponds are classified into three categories on the basis of the amount of total alkalinity present therein **(Carlson and Simpson, 1996)**. Values of TA ranging between 1 to 15 mg/L are considered to be 'oligotrophic pond', 16 to 60 mg/L are moderately rich in nutrient concentration 'mesotrophic', while TA greater than 60 mg/L are said to be nutrient rich pond 'eutrophic'**(Spence, 1967)**. As per the present classification, both the study sites (ACP and GVP) are considered to be eutrophic ponds. According to **Durrani (1993)**, utilization of CO_2 from HCO_3 for photosynthesis by algae may increase the amount of TA, which is the final endpoint for the alkalinity titration.

At pH 4.5, all carbonate and bicarbonate ions are converted into carbonic acid (H_2CO_3). This endpoint can be identified using a Methyl Red indicator. The indicator changes from green to pink at pH 4.5. Below pH 4.5, the water is less able to neutralize the sulphuric acid, and there is a direct relationship between the amount of sulphuric acid added to the sample and the change in the pH of the sample.

In case of surface water of GVP, TA was ranged between 120 to 1250 mg/L with peak content in the month of June (1250 mg/L), and lowest amount in the month of August (120 mg/L). On the contrary, TA content ranged from 230 to 630 (mg/L) with highest amount in May, and the lowest content in the month of August. Thus, the surface water of both study areas showed higher amount of TA during late summer, and lower concentration during late monsoon **(Tables 1, 2).**

Carbonates (CO_3^-)

The carbonate system is the sum of all inorganic forms of carbon, which represents the most important component of the total budget and turnover of carbon *i.e.* one of the main cycles of the turnover of substances in nature **(Sergey, 2010).**

In surface water of GVP, the contents of carbonates obtained during the study period ranged from 36 mg/L to 84 mg/L with minimum content in July (36 mg/L) and maximum amount in May (84 mg/L), whereas in case of ACP the lower amount was reported in the month of August (24 mg/L) and higher content in the month of February (199.20 mg/L) **(Tables 1, 2).**

Bicarbonates (HCO_3^-)

The carbonates and bicarbonates are the major components of alkalinity of surface water **(Muhammad *et al.*, 2000).** The surface water of ACP and GVP exhibited the fluctuating level of bicarbonates (19 to 1378.60 mg/L and 256.2 to 675.88 mg/L, respectively). Maximum bicarbonate content was recorded during late summer and early monsoon periods, while minimum amount was observed in the month of August (post monsoon phase) at both the study areas **(Tables 1, 2)**.

Total Hardness (TH)

Total Hardness (TH) is due to the concentration of alkaline earth metals. Calcium and magnesium ions are the principal cations imparting hardness **(Shinde *et al.*, 2011).** High concentration of hardness point out toward eutrophication of the aquatic ecosystem **(Rai, 1974)**. **Sawyer (1960)** classified water on the basis of hardness into three different categories *viz.* Soft water (0 to 75 mg/l), moderately hard water (76 to 150 mg/l) and hard water (151 to 300 mg/l). The total hardness of surface water of GVP ranged between 53.46 to 466.22 mg/L, and 56.42 to 577.82 mg/L in ACP. According to Sawyer's classification, both the studied ponds fall under hard water category.

Calcium and Magnesium Hardness

Calcium and magnesium are the most abundant elements in natural surface and ground water, which exists mainly as carbonates, bicarbonates and carbon dioxide contributing the main inorganic carbon source 'producers' in an aquatic ecosystem **(Shinde *et al.*, 2011).** Calcium and magnesium ions are the main principal ions imparting hardness to the water, and prevent leather forming. Magnesium occurs in all kinds of natural waters with calcium, and its concentration remains generally lower than calcium **(Trivedy and Goel, 1984)**. The similar trend was observed in surface water of both the studied ponds (GVP and ACP) during the present investigation. The importance of magnesium lies with the chlorophyll bearing algae and plants. In the present study, calcium content was ranged from 64.73 to 503.11 mg/L with the highest peak in the month of May (503.11 mg/L) and lowest peak in the month of August (64.73 mg/L) in GVP. Almost similar results were observed in case of ACP, where calcium content was found between 68.21 to 598.32 mg/L, of which maximum and minimum concentrations were recorded in the month of April (598.32 mg/L) and August (68.21 mg/L), respectively **(Tables 1, 2).**

While in case of magnesium hardness, the values were ranged between 46.20 to 220.50 mg/L for GVP and 48.30 to 147.00 mg/L for ACP. Higher contents were noted in January (for GVP) and November (for ACP). On the contrary, lower amount of magnesium hardness was observed in the month of August in both the aquatic bodies.

COMPARATIVE APPROACH

Different physico-chemical parameters of surface water were investigated for a consecutive twelve months (January to December 2010) to study the pollution status of the two pond ecosystems *viz.* ADIT Campus Pond (ACP) and Gana Village Pond (GVP). Analysis of Phenolphthalein alkalinity, total alkalinity, carbonates, bicarbonates, total hardness, and calcium and magnesium hardness were carried out. Derived results were further analyzed statistically to draw a streamline conclusion for the status of aquatic pollution of both the study areas **(Table 3)**.

Comparing the data of both the study areas, steep range of fluctuation were observed for all the physico-chemical parameters during the study period. ACP was found to be more impacted by anthropogenic pressures, as most the values were reported to be high for the aforesaid study site. Of all the studied parameters, phenolphthalein alkalinity, carbonates, total hardness, and calcium hardness were recorded to be higher compared to GVP.

ACP showed higher content of carbonates during winter (199.2 mg/L), and PA reached maximum peak during the month of January. This might be due to contribution of carbonate ions in increasing alkalinity **(Mahanada *et al.*, 2010). S**imilar trend was observed in case of TH, the findings of which are corroborated with the findings of **Hujare (2008)**. Higher values of hardness during summer can be attributed by the decrease in the water volume and increase in the rate of evaporation **(Anil and Puttiah, 2011).** This could also be due to an increase in the contents of calcium, magnesium, sulphate, carbonates, bicarbonates and phosphates (**Durfor *et al.*, 1964; Patel *et al.*, 1998).**

Other parameters such as total alkalinity, bicarbonates, and magnesium hardness were found to be elevated in GVP. High bicarbonate values were recorded in monsoon (1378.60 mg/L). Similar trends were observed by **Islam (2007)** and **Nirmal Kumar *et al.* (2008)**. Higher amount of total alkalinity and bicarbonates in GVP could be due to higher carbon dioxide concentration and peak release of bicarbonates by the sediments **(Sharifina *et al*., 2013). Sugunam (1995)** reported that total alkalinity above 40 mg/L is indicative of high productivity. The total alkalinity of the pond is an indication of inducing level of carbonates and bicarbonates with the possibility of silicates and phosphates contributing to it **(Wetzel, 2001)**.

CORRELATION APPROACH

Interrelationship studies between different variables are very helpful tool in promoting research and opening new frontiers of knowledge. The study of correlation reduces the range of uncertainty associated with decision making **(Mahanada *et al*., 2010).** The correlation coefficient (r) among various physico-chemical parameters for surface water was calculated for both the studied ponds (ACP and GVP). Antagonist relation was observed in case PA with all the other studied parameters. On the contrary, all the other parameters showed high positive correlation among one other. Positive correlation among aforesaid parameters suggests that all the positively correlated parameters are strongly interrelated among one other. While in case of ACP, PA was negatively correlated with TA and Bicarbonates, and rest of the parameters showed positive correlations **(Tables 4, 5)**.

MANAGEMENT AND CONSERVATION

Rural ponds are the primary water source for almost all the domestic uses, thus these ecosystem extends as a basic service of provisioning. But the non-segregated multiple, unstructured, impulsive use results in water pollution which affects the well being of the users, particularly the poor who have no alternative to theses source of water. To rule out these pollution issues certain stern measures should be taken and implemented consideration. Proper filtration method, assessment of hydrological, physico-chemical and hydro-biological features on regular intervals, implementation of disciplinary, stringent rules and regulation for the locales residing around the near vicinity of the ponds, strict prohibition of washing , bathing, gazing etc should be taken as an urgent initiate by the management committee to protect, conserve and manage the natural habitat persisting in and around the pond area and its diversity in a better and methodical way for the better sustenance and perpetuation of biotic components **(Carlson and Simpson, 1996)**.

CONCLUSION:

Concentration gradient of physico-chemical parameters of surface water can be represented as TA > HCO_3^- > Ca > TH > Mg > PA > CO_3^- for GVP, and TA > HCO_3^- > Ca > TH > CO_3^- > PA > Mg for ACP. Comparing the results of physico-chemical parameters of both the studied ponds, most of the

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parameters were exhibited by high amount in the surface water of ACP *viz*. carbonates, phenolphthalein alkalinity, total hardness and calcium hardness, whereas rest of the parameters such as magnesium hardness, bicarbonates and total alkalinity were reflected by the peak amount in GVP. Thus, the present study clearly reveals the extent of aquatic pollution at both the studied ponds. Moreover, ACP was found to be more polluted than GVP and impacted by anthropogenic pressures, especially dumping of a domestic as well as industrial waste.

The obtained data clearly predicts the extent of contamination at both the study sites leading to deterioration and degradation of water quality directly affect the sustainability of various biotic components of both the ponds, and indirectly causing a foremost reason for impeding an ecological imbalance of a particular an aquatic ecosystem. Keeping in mind the grave results, it is very essential and prime importance to convert these eutrophic states of both the wetlands to the oligotrophic state in order to protect its biodiversity prevails therein. The manifested results calls for the alarming note, need and urgency to restore the physical, chemical and biological integrity of these freshwater wetlands with viable and stringent restoration and management tactics in order to maintain, preserve, conserve and to prevent an ecological imbalance and disturbance in hydrological cycle, which ultimately affect the food chain and food web of an aquatic ecosystem.

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Table 1. Physico-Chemical Characteristics of Surface Water of Gana Village Pond (GVP)

Parameters	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	OCT	NOV	DEC	MIN	MAX	MEAN	S.D.
PA	270.0	174.0	60.0	70.0	76.0	44.0	115.0	20.0	40.0	56.0	58.0	20.00	270.00	89.36	72.99
TA	390.0	340.0	540.0	380.0	630.0	440.0	453.0	230.0	304.0	544.0	550.0	230.00	630.00	436.45	121.55
CO3	144.0	199.2	72.0	84.0	91.2	52.8	138.0	24.0	48.0	67.2	69.6	24.00	199.20	90.00	50.94
HCO3	0.0	0.0	585.6	378.2	675.9	483.1	412.4	256.2	322.1	595.4	600.2	0.00	675.88	391.73	232.88
TH	424.1	195.6	424.1	577.8	399.0	133.1	358.6	56.4	178.5	328.3	142.7	56.42	577.82	292.56	160.94
Ca	442.1	223.8	442.1	598.3	420.5	151.5	379.3	68.2	209.3	364.1	157.5	68.21	598.32	314.24	161.92
Mg	73.5	115.5	73.5	84.0	88.2	75.6	85.0	48.3	126.0	147.0	60.6	48.30	147.00	88.84	29.32

Table 2. Physico-Chemical Characteristics of Surface Water of ADIT Campus Pond (ACP)

Parameters	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	OCT	NOV	DEC	MIN	MAX	MEAN	S.D.
PA	270.0	174.0	60.0	70.0	76.0	44.0	115.0	20.0	40.0	56.0	58.0	20.00	270.00	89.36	72.99
TA	390.0	340.0	540.0	380.0	630.0	440.0	453.0	230.0	304.0	544.0	550.0	230.00	630.00	436.45	121.55
CO3	144.0	199.2	72.0	84.0	91.2	52.8	138.0	24.0	48.0	67.2	69.6	24.00	199.20	90.00	50.94
HCO3	0.0	0.0	585.6	378.2	675.9	483.1	412.4	256.2	322.1	595.4	600.2	0.00	675.88	391.73	232.88
TH	424.1	195.6	424.1	577.8	399.0	133.1	358.6	56.4	178.5	328.3	142.7	56.42	577.82	292.56	160.94
Ca	442.1	223.8	442.1	598.3	420.5	151.5	379.3	68.2	209.3	364.1	157.5	68.21	598.32	314.24	161.92
Mg	73.5	115.5	73.5	84.0	88.2	75.6	85.0	48.3	126.0	147.0	60.6	48.30	147.00	88.84	29.32

Table 3. Minimum, Maximum and Mean Values of Physico-Chemical Properties of Surface Water of GVP and ACP

	MINIMUM		MAXIMUM		MEAN	
PARAMETERS	**GVP**	**ACP**	**GVP**	**ACP**	**GVP**	**ACP**
PA	30.00	20.00	210.00	270.00	66.09	89.36
TA	120.00	230.00	1250.00	630.00	496.91	436.45
CO3-	0.00	24.00	84.00	199.20	56.40	90.00
HCO3-	0.00	0.00	1378.60	675.88	468.26	391.73
TH	53.46	56.42	466.22	577.82	237.32	292.56
Ca	64.73	68.21	503.11	598.32	266.99	314.24
Mg	46.20	48.30	220.50	147.00	121.58	88.84

* *Values are expressed in mg/L.*

Table 4. Correlation Coefficient for Physico-Chemical Parameters of Surface Water of GVP

Parameters	PA	TA	CO3	HCO3	TH	Ca	Mg
PA	0.000						
TA	-0.130	0.000					
CO3	-0.643	0.555	0.000				
HCO3	-0.236	0.994	0.594	0.000			
TH	-0.143	0.395	0.571	0.386	0.000		
Ca	-0.162	0.388	0.559	0.382	0.998	0.000	
Mg	-0.315	0.158	0.219	0.191	0.609	0.660	0.000

Table 5. Correlation Coefficient for Physico-Chemical Parameters of Surface Water of ACP

Parameters	PA	TA	CO3	HCO3	TH	Ca	Mg
PA	0.000						
TA	-0.080	0.000					
CO3	0.823	0.012	0.000				
HCO3	-0.690	0.760	-0.560	0.000			
TH	0.334	0.371	0.296	0.110	0.000		
Ca	0.999	0.373	0.304	0.109	0.999	0.000	
Mg	0.022	0.087	0.205	0.001	0.115	0.159	0.000