Urban Lakes - relationships between source water, lake age, water chemistry, and biota

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Fountain Hills, a 26 year-old urban lake developed with effluent source water.

Abstract

More than 50 urban lake systems exist in Maricopa County. The urban lakes were created to serve recreational, aesthetic, and flood control purposes, and were generally constructed in an opportunistic manner whenever water rights could be secured. Although individual lake owner's associations have conducted some level of aquatic monitoring over the years, little effort has been made to bring preexisting data sets together or to systematically investigate the lakes. The objective of this study was to determine how water chemistry, primary production, and algal populations in the urban lakes are related to lake age, water source, and other lake characteristics. To achieve the objectives of this study six urban lakes were selected to maximize variations in age and water source (canal, well, effluent). Monthly water sampling, over the course of 1999, examined a variety of physio-chemical parameters, including major ions, nutrients, selected metals and organics. Water samples were also examined for algal biomass and genera composition. Selected data will be presented to compare aspects of the biology and chemistry for the six lakes.

Introduction

Many limnological studies have been performed on large artificial and natural lakes. Relatively ignored have been the small urban artificial lakes constructed as part of many subdivisions, golf courses, industrial parks and planned communities. Urban lakes are usually designed to serve economic, recreational, aesthetic, and flood control purposes. For example the recently built Rio Salado Town Lake project in Tempe, Arizona is the centerpiece of a large economic development plan. Besides economic gain, Rio Salado is also slated to have broad recreational benefits for the entire urban community. The Phoenix metropolitan area, one of the fastest growing urban centers in the United States, has seen a substantial increase in the number of these water bodies.

Limnological features of the desert urban lakes are somewhat unique compared to other aquatic systems. The high light environment, warm temperature and shallow depths of the lakes create highly productive aquatic systems. High evaporation rates and the lack of water flow through may also create opportunities for concentrating nutrients and pollutants from source water and urban watershed runoff.

The objectives of this study were to (1) determine how chemistry, primary productivity, and algal composition in the urban lakes are related to water source type and lake age, (2) evaluate the water quality changes in an urban lake over approximately a decade and (3) collect urban lakes water quality data as a baseline for long term monitoring by the Central Arizona Project Long Term Ecological Research Project.

Methods

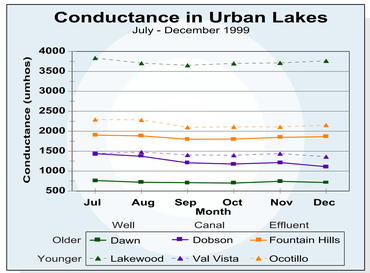
To achieve the objectives of this study six urban lakes, for which there is historical data were selected. The lakes are Dawn, Dobson Ranch, Fountain Hills, Lakewood, Ocotillo, and Val Vista. This selection provides two lakes of each source water type: canal, well, and reclaimed effluent and three lakes of each age class: 12-13 years old and over 20 years of age.

	Lake Water Source	Well	Canal	Sewage
Age Class				
Older Lakes	**Lake Features**			
	Urban Lake	Dawn	Dobson	Fountain H.
	Age	30	23	26
	Area km^2	0.177	0.012	0.152
	Aeration	NO	NO	YES
	Circulation	NO	NO	NO
	Storm Drainage	NO	YES	YES
	Perimeter km	3.7	0.64	3.22
	Perimeter/Area km/km^2	21	53	15
	Shore Line Dev. Factor	2.48	1.64	1.61
Younger Lakes	**Lake Features**			
	Urban Lake	Lakewood	Val Vista	Ocotillo
	Age	12	12	13
	Area km^2	0.084	0.105	0.023
	Aeration	YES	YES	YES
	Circulation	NO	NO	NO
	Storm Drainage	YES	YES	YES
	Perimeter km	2.32	3.05	1.84
	Perimeter/Area km/km^2	28	29	81
	Shore Line Dev. Factor	2.25	2.65	3.46

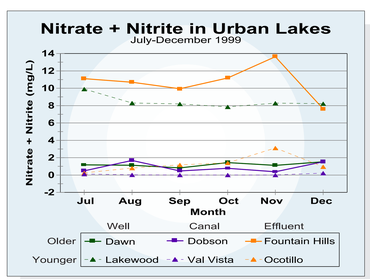
In each lake system the first lake receiving source water was sampled. Sampling occurred in the center of each lake and the samples were composited for three depths: surface, mid - depth, and bottom. Monthly water sampling, over the course of 1999, examined secchi depth, pH, conductance, dissolved oxygen, dissolved total nitrogen, dissolved total phosphorus, dissolved organic carbon, particulate carbon, particulate nitrogen, and chlorophyll a.. Bimonthly the water samples were examined for algal density and composition. Water chemistry parameters irregularly collected during 1999 included cations, anions, Cu, Pb, Zn, benzene, toluene, ethyl benzene, xylene, and dissolved inorganic carbon.

Results and Discussion

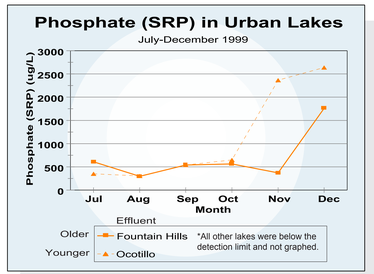
Presented below is six months, July - December 1999, of conductance, nitrate + nitrite, phosphorus, dissolved organic carbon, chlorophyll a and secchi data. Except for conductance and secchi data each graphed point is an average of 3 replicates.



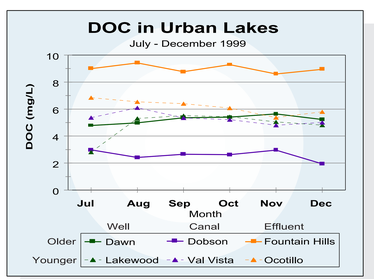
Conductance in the individual urban lakes was stable during the six months of monitoring. The two lakes with canal water sources, Dobson Ranch and Val Vista, had a similar conductance even though the age of the lakes was quite different. The two lakes fed by effluent water also had a similar and somewhat higher conductance. The two lakes with well source water differed greatly in conductance. Lakewood had a conductance almost 5X greater than Dawn lake over the sampling period. Lake age did not seem to be related to increases in conductance.



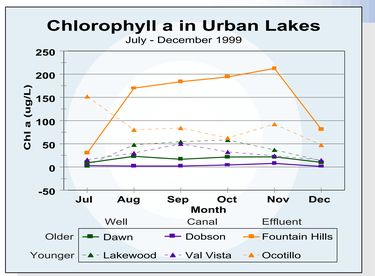
Nitrate + nitrite concentrations differed among the lakes but were distributed into two rather distinct groups. The two lakes with the highest nitrate + nitrite were Fountain Hills and Lakewood with effluent and well source waters, respectively. The nitrate + nitrite was greater in Fountain Hills than Lakewood. In the second group of lakes the nitrate + nitrite concentration was consistently below 3 mg/L during sampling. The nitrate + nitrite results do not show any trend based on lake age. Both the highest and lowest concentrations of nitrate + nitrite were recorded from the two oldest study lakes.



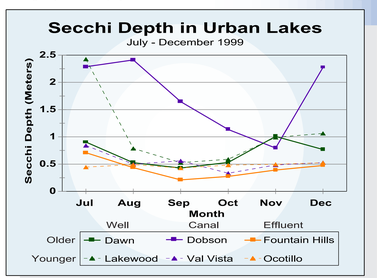
Soluble reactive phosphorous (SRP) was only detectable in the two effluent lakes sampled. During the six months of sampling the canal and well lakes measured below the 3.1 ug/L detection limit for the procedure. The SRP concentration in the effluent lakes was measured for six months significantly above 20 ug/L. During July 1999 Fountain Hills had a greater SRP concentration then Ocotillo. The SRP concentration between the effluent lakes was similar for the months of August, September, and November. Both effluent lakes had large increases in SRP concentration during the end of the sample period. Ocotillo's SRP increase occurred in October while Fountain Hills' SRP increase occurred in November. Ocotillo the younger effluent lake had the highest average SRP concentration during the six months of monitoring. Lake age did not seem to influence SRP levels.



Dissolved organic carbon (DOC) in the six lakes remained relatively constant over the six months sampled. The only notable change occurred in Lakewood between July and August when the concentration increased more than 2 mg/L. The DOC in Lakewood then remained relatively constant at the increased concentration from August to December. The lakes fell into three groups. Fountain Hills consistently had the highest concentration of DOC that averaged approximately 9 mg/L. The DOC in Dawn, Lakewood, Ocotillo, and Val Vista lakes was similar and occupied a middle range of concentrations from 5 to 7 mg/L. Dobson Ranch lake #1 was consistently the lake with the lowest measured DOC concentration with a six month average of 2.5 mg/L. The two effluent lakes typically had the highest concentrations of DOC, though Fountain Hills' DOC concentration was at least 2 mg/L greater than Ocotillo's each month. Lake age did not seem to influence DOC concentrations.



The six month average chlorophyll a concentrations are listed in descending order as follows: Fountain Hills, Ocotillo, Lakewood, Val Vista, Dawn, Dobson Ranch. The two effluent lakes had the highest average chlorophyll a values while the other lakes did not form distinct groups. Chlorophyll a concentrations were not influenced by lake age.



Secchi depth tended to vary inversely with chlorophyll a concentrations. Water clarity was lower in effluent lakes and greater in well and canal lakes. Fountain Hills and Dobson Ranch had the lowest and highest water clarity, respectively.

Conclusions

1. Conductance was relatively constant in each of the lakes, although there were major differences between lakes. Conductance was not influenced by lake age.
2. Nitrate + nitrite concentrations were low and similar in most of the lakes except for Lakewood and Fountain Hills. Source water type could not explain observed nitrate + nitrite concentrations.
3. SRP was measurable only in the effluent lakes.
4. Lakes fed by effluent sources had the greatest algal biomass and would be classified as eutrophic. The other well and canal lakes appear to be mesotrophic in nature. Of all the lakes, Dobson Ranch was the least productive.
5. Lake age did not appear to be a factor in explaining the differences in water chemistry of the six lakes. Water retention characteristics, however, may be a major factor in determining lake chemistry.

Acknowledgements

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