Evaporation pond as a refuge for aquatic birds in "Cerro Prieto" Geothermal Field, Baja California, Mexico

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Key words: geothermal field, evaporation pond, migrant aquatic birds, wintering refuge.

Abstract :

"Cerro Prieto" Geothermal Field. the most important geothermal power plant in Mexico and Latin America. is located at the northern portion of Baja California, Mexico . Perforation activities began in 1964 by 1980 an evaporation pond was created to hold the water discharged from the generation plants and wells. During a winter sampling period (February and March 1994) 34 bird species of 13 families were detected inhabiting the evaporation pond. An analysis of their abundance and distribution in different sites of the pond indicates that migrant. birds spending the winter in the area, are threatened because of the high concentrations of chemical compounds. mostly at the central portion of the pond. Some comments and suggestions are included concerning the conservation of the pond as a winter refuge for migrant aquatic birds.

Introduction

In general, the development of hydro-electric power plants is associated with the construction of artificial water bodies and ancillary activities such as agricultural irrigation systems. Geothermal power plants, however, represent a special case. Due to the high temperature of the water produced. and to the presence of compounds dissolved and/or in suspension, it has been necessary to construct special impoundments to keep the water confined, allowing the sedimentation of solids in suspension arid the decrease of its temperature.

The colonization of new areas by living organisms happens as a natural process. when the characteristics of the site are favorable to the organisms; on the other hand! if the site does not represent an appropriate habitat, because of the absence of resources or protected sites, the organisms will not stay in that location, no matter how frequently they arrive as possible colonizers (Wiens 1989). Since the creation of an evaporation pond at the Cerro Pricto Geothermal Field (CPGF), the arrival of populations of migrant aquatic bird species that breed in the United States and Canada has been observed. In their migration south, during the months when temperatures are low, this warm pond is attractive to birds and allows them to maintain themselves in the area during the winter, without traveling farther south in search of places with favorable conditions. Due to the great number of individuals that inhabit the pond duiing the winter, the authors were able to determine which bird species use the pond as a wintering refuge. to determine their abundance, and their preference for certain sections of the pond. Comments concerning with the problems associated to the conservation of the area as a refuge site for migratory aquatic birds are presented in this paper.

Study area, materials, and methods

CPGF is the most important geothermal power plant in Mexico and Latin America, and is third at a worldwide level. It is located in the flatland of the Mexicali Valley, 30 km SE of Mexicali, Baja California (32"22'-32" 26'N, 115° 12'-115° 18'W), within the Geological Sub-province of the Colorado River Delia, at the base of the Cucapah Mountain Range and next io the Cerro Pricto Volcano (CFE 1992). Its climate is and and severe, with a mean temperature of 22.1 °C (ranging from - 2 to 47 °C); the mean annual precipitation is 80 mm (Garcia 1988).

In order tu contain the water discharged by the power plants, an evaporation pond was constructed during 1980-1981. Presently, its extension is approximately 18.6 km^2, and has a capacity of 4,216,892 m^3. The pond designed in a "snail" shape. permits silica sedimentation and a decrease of the water temperature simultaneously. As a result of the evaporation process, the concentration of dissolved compounds (such as Arsenic and Boron) increases in their trajectory towards the central portion of the pond.

The biota of the pond inlcudes several introduced fish (*Micropterus salmoides* and *Cyprinus carpio*) and numerous birds, mostly during the winter season. Among the plants, there are patches of emergent vegetation composed by *Larrea tridentata* and *Pluchea cerieeae*, that provide covered and protected sites; marine grasses of the genus *Phyllospadix* are abundant.

Direct count censuses were conducted between 0700 and 1030, during two sampling periods (3-5 February and 21-23 March 1994) in different sections of the pond. During each census, all the bird species as well as their numbers were recorded. Binoculars (7 x 35) and a telescope (UNITRON 80 mm) were used for the observations. Sampling sites were established, taking in consideration the presence or absence of emergent vegetation, maximal depth, and distance from the water discharge site (Figure 1 arid Table 1). Guild groups of birds were established, considering the similarities in the way they obtain their food and general habits (Tahle: 2). The guild groups were: (a) "ducks, pelicans and allies", those that obtain their food by diving or by continuous search while swimming, (b) "shorebirds", which inhabit shallow sites seeking their food in the mud, (c) "gulls and allies", including those members of the Laridae family, (d) "herons", including the species of the Ardeidae family, that get their food passively, while waiting in the water for small mobile organisms, (c) "raptorials", including the birds of prey, and "landbirds", including only a pigeon and a sparrow.

Table 1. Characteristics of the sampling sites within the evaporation pond of "Cerro Prieto" Geothermal Field, Baja California, Mexico.

Site	Distance from the site of water liberation (m)	Emergent vegetation	Maximum depth (m)
Central Zone	1,600	Present	3.00
Northern Zone	3,000	Present	0.60
"Carrizal" Pond	2,500	Absent	1.55
Northwestern Zone	2,750	Absent	0.55
"Abanicos aluviales"	2,750	Present	0.30
Southern Zone	3,000	Present	1.50
Southeastern Zone	2,400	Absent	2.70
Volcano Lagoon	2,500	Absent	0.75
Shallow Lagoon	1,400	Absent	0.20

Source: CFE 1990. Análisis químico de la laguna de evaporación solar. Reporte Interno. Departamento de Química Ambiental, Residencia General de Cerro Prieto, Comisión Federal de Electricidad, 2 pp.

Results

A total of 41 censuses were carried out at the different pond sites during the months of February (n=21) arid March (n=20), detecting a total of 24,450 individual birds, belonging to 34 species and 13 families (Table 2). Four species were observed out of the census period and were not registered. These species were *Falco sparverius*, *Phalaropus fulicarius*, *Sterna hirundo* and *Zenaida asiatica*.

The size of the bird community exhibited an average decrease of 40% in March, with respect to the month of February. In general, the group of "ducks, pelicans and allies" was the most abundant, representing an average of 91.5% of the total, with 22,372 individuals of 15 species, followed by the "shorebirds" (8 species) and "gulls and allies" (3 species), which comprised 6.1 and 1.4% of the community respectively. "Raptorials", "herons" and "landbird" species totaled 246 individuals of 8 species, which represented 1% of the community. It is important to point out that, for the individuals of "herons" and "gulls" the pond is used mainly as a place to overnight; during the early morning censuses the recorded numbers of these groups were low! as a result of their dispersion during the day when they search for food in neighboring places.

Table 2. List of aquatic bird species recorded within the evaporation pond at Cerro Prieto Geothermic Field, Baja California, Mexico

Species	Individuals detected	Guild group[1]
Podiceps nigricollis	1,256	
Aechmophorus occidentalis	50	
Pelecanus erythrorhynchos	109	
Pelecanus occidentalis	1	
Phalacrocorax auritus	235	
Ardea herodias	1	d
Casmerodius albus	182	d
Egreta thula	14	d
Ghen caerulescens	8	
Anas acuta	1,657	
Anas clypeata	862	
Anas americana	1,415	
Aythya valisineria	3	
Aythya americana	1,306	
Bucephala clangula		
Bucephala albeola	1	
Oxyura jamaicensis	254	
"Ducks"	13,031	
Pandion haliaetus	3	
Circus cyaneus	1	
Haliaetus leucocephalus	1	
Fulica americana	13.	a
Charadrius vociferus	12	n
Recurvirostra americana	408	b
Himantopus mexicanus	334	b
Tringa melanoleuca	5	b
Tringa solitaria	6	h
Catoptrophorus semipalmatus	7	b
Calidris minutilla	649	b
Limnodromus scolopaceus	1	b
Larus philadelphia	2	
Larus	1 6	
Larus sp.	ass	
Sterna maxima	12	
Zenaida macroura	17	f
Melospiza melodia	5	

1 = a: Ducks, pelicans and allies; b: shorebirds; c: gulls and allies; d: herons; e: raptorials; f: landbirds.

With respect to tbe spatial distrihution of birds, the individual bird proportions in the sampling sites of the pond showed significant differences (G^2=15.72, df=8, p=0.015). The Central Zone supported the highest numbers of birds (71.3%), fol'owed by the sites with emergent vegetation such as "Abanicos Aluviales" (6.2%), the Southern Zone (5.6%), and the Northern Zone (5.4%). The sites leapt inhabited were the shallow sites lacking vegetation, such as the Shallow Lagoons (1.1%), "Caracol" Pond (1.2%), and Volcano Lagoon (1.5%).

Discussion

Undoubtedly, the evaporation pond represents an important wintering refuge
far the aquatic migratory birds that have become habituated to its particular conditions. In the first sectors of the pond. because of the high quantities of silica in suspension, the muddiness reduces the visibility and the. penetration of light, resulting in low photosynthetic levels. The higher, temperatures, at the same time, imply low concentrations of dissolved oxygen (Cairns 1978), suggesting low productivity levels. However, the presence of abundant marine grasses is indicative of a higher productivity at the farthest portions from the site of the geothermal water discharge. where the temperature is lower and the muddiness of the water is almost absent.

As the results indicate. the major concentrations of birds are found in sites where emergent vegetation is present, and water visibility allows them to find their food items. On the other hand. human activities could be invoked in this distribution, considering tha: the central portions usually are not affected by perforation activities and tlic transit of vehides. Moreover, concentrations of shorebird species in shallower sites indicate the presence of invertebrate organisms on whid thei diet is based. According to Colwell and Landrum (1993), thir group of spies responds mainly to the abundance of prey, besides other factors such as substrate and salinity. Although studies have not been done on this subject, thir suggests the existence of an important community nf benthonic invertebrates rhar supports the shnrebird species.

Due to the evaporation process, concentrations of dissolved chemical compounds increase gradually; among those Boron and Arsenic are found at concentrations up to 37 0 and 1.343 PPM rzspectivcly, at the center of the pond (CFE 1990). *So* far, the study on thr effects of chemical compounds in birds has been centered in rhe chlorinated hydrocarbons, such as DDT widely used in the past, due to its influence on the low rates of reproductive success (resulting in the thinning of egg shells of fish-eating and raptorial species; e.g Hickey y Anderson 1968, Blus et al., 1974, 1977, 1980); moreover, selenium compounds present in irrigation waters, are principally responsible for deformations and a significant decrease in birds' productivity (Ohlendotf et al. 1993). However. up to now the effect of the accumulation of boron and arsenic compounds in animal tissues is not understood, although it is known that they are bioaccumulable and could he related to cancer development in man (DOF 1989). Although these elements are natura: components of the terrestrial cortex, and organisms are exposed to them during their lives, it is necessary to determine the effects of high concentrations in the local conditions. Considering migrant organisms such as birds. probably it is nut possible to observe their effects directly, since their breeding occurs during the summer in the United States and Canada. These effects will *bc* seen mainly in the species occupying the highest levels of ths trophic chain, for which the concentration of toxic compounds will be higher. Because trf this, long term monitoring is important.

Conclusions

Considering the particular conditions of the pond, birds that use it as a wintering refuge tend tu concentrate in the central portions, which contain the highest concentration of hazardous compounds.

In order to preserve this site as a winter refuge tor migrant birds the recommendations arc:

a) To continue censusing the area tu determine the fluctuations of the bird community during the year.

b) to carry out studies on the biota of the pond. including the composition of plant communitics! plankton, macroscopic invertebrates, and fish, that sustain the bird community during the winter.

c) to analyze the chemical composition of animal and plant tissues, in order to determinc the degree of accumulation of toxics, and conduct bioassays to determine their long term effects.

d) to determine tlic fluctuations on the concentration of dissolved and/or suspended compounds in the water during the year in the different zones of the pond. Since the pond is a reservoir that confines: geothermal water Over the long terrn, the concentration of compounds is potentially harmful and it could represent a truc danger for its wildlife in the future.

e) to find an industrial use for the silica thai accumulates in the first sections of the pond.

f) tu develop mechanisms to reinject the water to the geothermat souce at deep levels, mainly from the areas where the concentration of dissolved chemical compounds is higher (central zonc), lessening the concentrations of chemicals that could he deleterious to wildlife in ilie long term.

g) to explore the possibilities of water treatment by means of microbial biochemical processes that could be technically and economically feasible.

Acknowledgements: The authors thank Ivonne Juárez for her support during the field work. Biol. Gerardo Ceballos for the taxonomic determination of the marine grass genera, and an anonymous reviewer, whose suggestions and notes improved substantially this paper.

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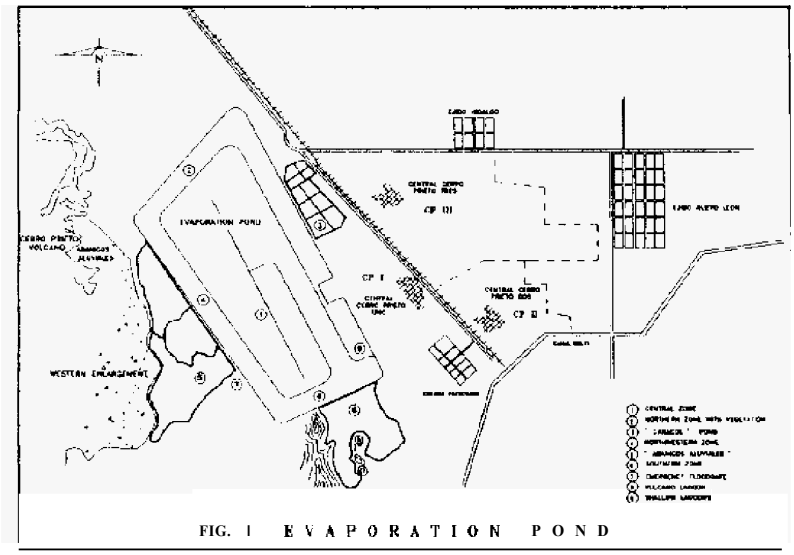

FIG. 1 EVAPORATION POND