2012 International Conference on Environment, Energy and Biotechnology
IPCBEE vol.33 (2012) © (2012) IACSIT Press, Singapore

Using a Geo-environmental Index to Diagnose and Prevent Environmental Pollution by Trace Metals in the Texcoco Lake Ecological Park, Mexico.

Jaime San Román Sierra[1], Norma P. Muñoz–Sevilla[2], Miguel Á. López-Flores[2]and Pedro Joaquín Gutiérrez- Yurrita[2+]

[1] Aguas del Valle de México –Comisión Nacional del Agua

[2] Centro Interdisciplinario de Investigaciones y Estudios Sobre Medio Ambiente y Desarrollo- Instituto Politécnico Nacional

Abstract. The basin of the former Lake Texcoco is located in the heart of one of the most populous metropolitan areas in the world: Mexico City (MAMC). However, although the lake is a drying vessel of more than 90%, of their geophysical characteristics has not been completely urbanized, making it the ultimate outdoor space for the overcrowded population of the north-east; but at the same time, it is a considerable source of contamination for periphery-urban area by the large dust storms that are generated. And the amount of several toxic substances, which flow through their channels of wastewater. To reverse the harmful effects on human health and prevent pollution reaching the aquifer, the National Water Commission (NWC) has established the Lake Texcoco Ecological Park (LTEP). The purpose of this study was to have a bio-geochemical diagnosis of the LTEP like background information to develop its comprehensive management plan. So, to know the sources of contamination, identify and quantify contaminants in rivers, sediment and soil were analysed 27 factors LTEP physicochemical under NOM-001-SEMARNAT-1996, there were 11 vertical electrical soundings, 33 CT Electrical Resistivity. Three sources of pollution produced by human activities (industrial, urban and agricultural) and two sources of mixed origin (natural-anthropogenic) hyper saline water, salinization of soils and sediment were detected. Several parameters measured far exceed the maximum permissible limits established in NOM-001. We found an effect of soil washing in the crevices of saline soils, being more pronounced at south of the polygon PELT.

Keywords: Environmental manage, Heavy metals, Salt lake, Vertical Electrical Soundings.

1. Introduction

The proposed solutions to various environmental problems can be obtained by cross-disciplinary studies such as geo-environmental studies. This kind of studies can diagnose the state of a system and propose one integrative answer to the problem [1].Geo-environmental studies generate fast and confident information from techniques and methodologies of the earth sciences, particularly geophysics, geochemistry, biology and ecology [2].This kind of information is very important to develop policies to prevent environmental damages to ecological systems as well as to the human population. Protected natural areas near large metropolitan areas are subject to much pressure by pollution of various types(urban, industrial and agricultural, mostly), which can put in risk communities that surround it. This is the case of the Texcoco Lake Ecological Park, in the State of Mexico, Mexico (PELT).

The PELT borders the urban area of Mexico City. And more than 22 million people around it puts pressure on the authorities to change the land use of PELT, while, enjoying the environmental services generated [3]. However, the abandonment in which was this region until the recent creation of PELT, has produced more damage to health than benefits for people [4].These damages are not new to the inhabitants of

[+]Corresponding author tel.: +0052 5557296000 Ex. 52707; fax: +0052 5557296000 Ex. 52709.
E-mail address: pgutierrezy@ipn.mx / malopezf@gmail.com

the region. Since pre-Hispanic times there were sanitation sewage of major cities discharging to the Lake, until the excessive growth of the city, the King Moctezuma asked Nezahualcoyotl Emperor for permission to use as drinking water from the Chapultepec springs [5].

Under the perspective of conservation biology, with holistic approach, the importance of the region-encompassing PELT, is that the Lake of Texcoco is one of the few saline soda-lake in the world, and it is located into anendorheic basin [6].The basin is part of the neo-volcanic axis and cross stands as a transition zone between two bio geographic regions of North America: Neotropical (South) and the Nearctic (North); this area is also a point of ecological transition among different aquaticeco regions of North America. So, local biodiversity is enhanced by species from each geographic region, plus the endemicones [7].Another important aspect is that Lake of Texcocobyits natural hydrology, is concerning to its very marked hydro periods and water system, and providing a refuge for large flocks of several species of birds, both migratory and resident. 133 species of birds counted, with an overall density of population, more than350,000 individuals have come to occupy this habitat [8].The loss of flooded area has affected the biological extinction of many species and many others are listed as threatened or endangered.

PELTenvironmental diagnos is made in 2011 found that the presence of heavy metals was a serious problem requiring specialized carefast, since the accumulated trace metals are in sediment sand water for irrigation products for human consumption, mostly [1].

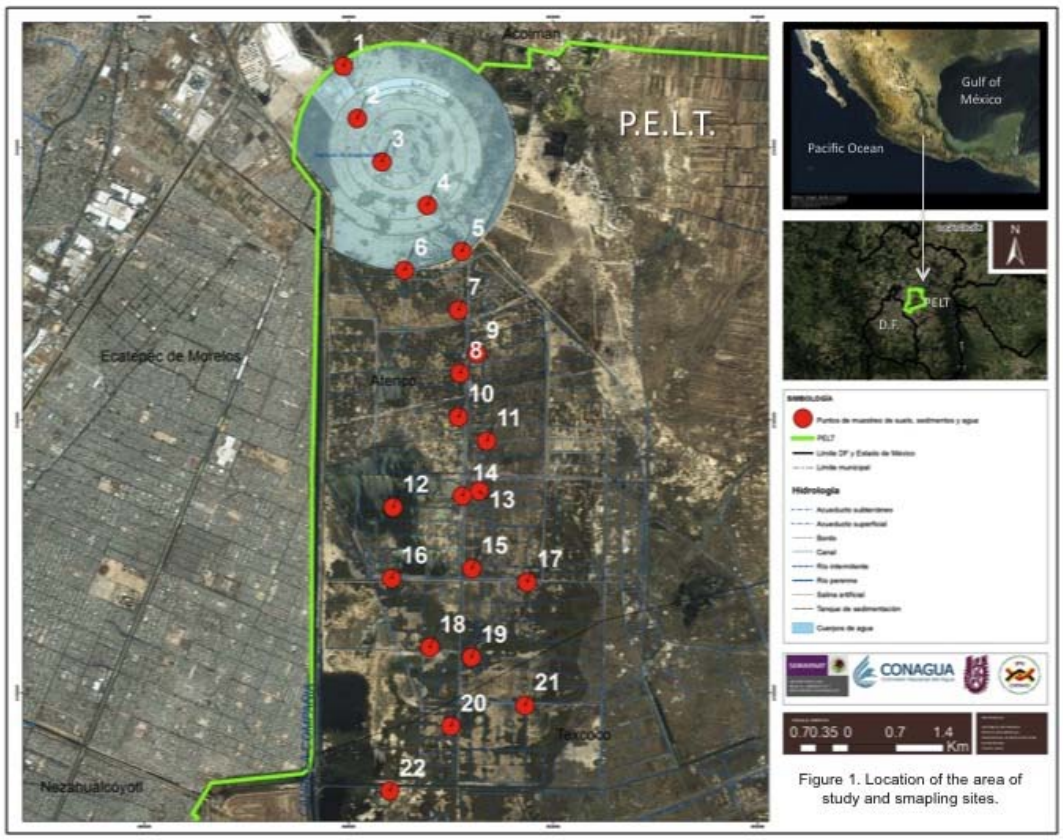

Figure 1. Location of the area of study and smapling sites.

2. Objective

To estimate an index on the basis of geoenvironmental heavy metals in sediments and water systems (winter-pools, rivers and sewage channels) which will facilitate the understanding of the ecological functioning of former Lake Texcoco in accordance to its presents human uses, where the PELT is located.

3. Materials and methods

3.1. Sampling

The field work was conducted during winter season because is the driest season of the year in the region, and thus, when people use more intensively the scarce winter-pools and rivers to irrigate their agricultural fields. Theoretical sampling for analysis of the environmental quality of the palustrine systems in

thePELTwassystematic.22 sampling sites were carefully chosen in accordance to the microhabitat characteristics to get a complete representation of all environmental diversity in the PELT (Fig. 1.).The methods used to characterize the factors that could endanger human health were obtained from the Mexican Official Standard of Health (NOM 127-SSA1-1993) to be more rigorous than environmental Official Mexican Standard. The other environmental factors were measured with the procedures authorized by the NOM-001-SEMARNAT-1996, which is specific to environmental quality, designed to preserve life and ecological functions in environmental systems.

3.2. Data analysis

Geo-environmental indices (Igeo) serve to make comparisons between the natural concentrations of metals, with respect to concentrations introduced by human [2]. In order to assess natural and induced concentrations of trace metal, these studies include the analysis of physical and chemical properties of water (both discharge and industrial urban complex) and, the determination of trace metals. The following equation was used for the calculation of the geoenvironmental index [9].

$$I_{geo} = \log_2 [C_n / (1.5\ Bn)]$$

Where: I geo= Geoenvironmenal Index; Cn=measured concentration of the metal "n" in the sediments and water examined; Bn =geochemical background concentration of metal "n".Thefactor1.5 is used because of possible variations in background values for a given metal in the environment with little or anthropogenic influences soil lithology [10].The index results are interpreted under the following criteria:

Class	0	**Range**	≤ 0	**legend**	Not polluted.
	1		0-1		Unpolluted to moderately polluted.
	2		1-2		Moderately polluted.
	3		2-3		Moderate to heavily polluted.
	4		3-4		Heavily polluted
	5		4-5		Strongly polluted.

4. Result discussed

Table I shows I-geo´s of 16 heavy trace metals from the PELT water and sediments. Metals in black background are significantly higher than expected parameter form natural conditions. In general conditions, two places of the PELT are moderate to heavily polluted [class 3] levels of Al, Ba, K and V. And just one case of heavily polluted for Mg [class 4].

Table 1: Proportions of I-geo of each heavy metal measured in water and sediment into the Texcoco Lake Ecological Park. 22 sampling sites were considered into de PELT in winter.

Class	Al	As	Ba	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Ni	Pb	V	Zn
0	22.78	100	0	0	18.18	0	100	63.63	100	4.55	4.54	100	0	100	9.09	100
1	36.36	0	0	100	81.82	100	0	36.36	0	4.54	0	0	100	0	13.64	0
2	36.36	0	86.36	0	0	0	0	0	0	22.73	0	0	0	0	72.73	0
3	4.54	0	13.64	0	0	0	0	0	0	68.18	4.54	0	0	0	4.54	0
4	0	0	0	0	0	0	0	0	0	0	54.55	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	36.36	0	0	0	0	0

It is worthy to notice that high toxic metals like arsenic (As), cupper (Cu), lead(Pb), mercury (Hg) and manganese (Mn) are present in natural conditions; just like trace metals and they do not represent serious damage to the human population neither to the wildlife. Figure 2 shows graphically the areas of higher levels of trace heavy metals into the PELT, due to human activities.

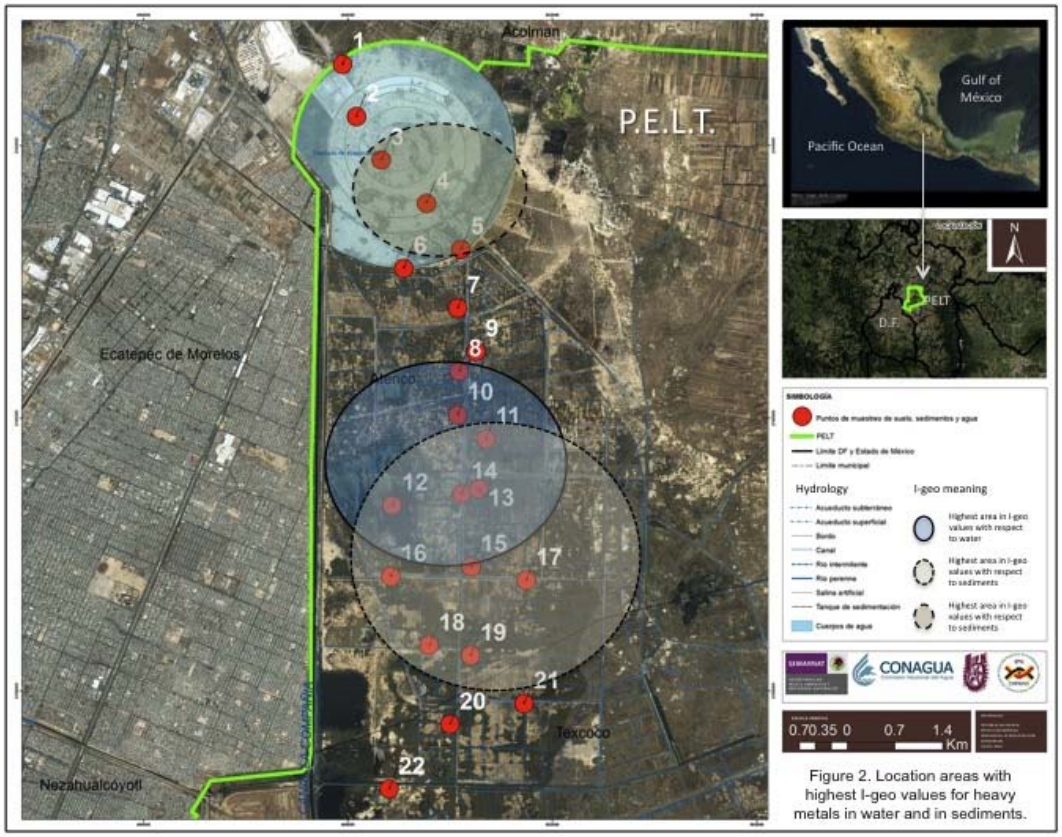

Figure 2. Location areas with highest I-geo values for heavy metals in water and in sediments.

Table II shows the most striking physico-chemicals in PELT water bodies, in the sense that this factors are higher than those permitted by law for waters to preserve wildlife. The other factors are inside the environmental law permissible limits. Parameters of chlorides, phosphates and sulphates are higher than those authorized to irrigate agriculture fields for human consumption products.

Table 2: Physicochemical of PELT water bodies.

Site	TDS (mg/l)	TSS (mg/l)	PO (mg/l)	SO (mg/l)	Cl (mg/l)	COD (mg/l)	BOD_5 (mg/l)	Nt (mg/l)	Grease & oils (mg/l)	Faecal (C/100ml)
3	15943	60	11.30			1181	382	**40**	14.5	NCD
4	14607	120	10.80	768	4963	1196	373	10.0	10.8	NCD
5	16636	17	11.40	813	4268	621	218	8.0	12.7	NCD
6	13753	67	10.10	895	4814	1098	372	13.0	11.5	NCD
7	9807	33	6.70	585	3871	746	287	9.0	13.3	NCD
12	53647	370	11.10	704	2233	2477	938	3.0	7.8	N.D
14	1280	933	<0.35	1018	17966	160	60	111.9	*	*
16	64550	23	82.40	163	533.0	1519	525	*	44.0	NCD
17	27910	37	40.40	990	*	2064	603	35.70	32.3	NCD
20	560	533	<0.35	910	*	131	53	30.1	*	*
22	1493	70	<0.35	145	24.0	1362	478	*	28.1	2400

TDS: Total Dissolved Solids; TSS: Total SuspendedSolids; PO: Phosphates; SO: Sulphates; Cl: Chlorides; BOD_5: Biological Oxygen Demand at 5 days; Chemical Oxygen Demand; N_t: total nitrogen;ND: no colonies detected; *: no data available.

5. Conclusions

According to the integrated I-geo results we can infer that the PELT is located in a region with two different kinds of salts in sediments and water. Hyper-saline sediments and hyper-saline water in NW and in the W of the PELT is due to the high concentrations of Mg and K. While areas close to the SE and NE are saline because of the Na. The above data are also directly correlated with the I-geo's for Al, Ba, Mg, Fe, Zn and K. It is important conduct some studies concerning the origin of heavy metals that exceed the natural values of the palustrine region in order to get some directions to control them. It is also important to recognize the compounds presents in soil, sediment and water to know how to clean up the system, especially for those salts with Mg.

Although faecal coliforms are inside the law limits, we wanted to incorporate it in the Table, because it is important to notice that although PELT is located into a high metropolis, no bacteria were detected in water, sediment and soil. Water quality is no good for agricultural activities.

6. References

[1] San Román Sierra, J., Muñoz Sevilla, N.P., Gutiérrez-Yurrita, P.J., Rodríguez-Espinosa, P.F. & López-Flores, M.A. 2011. *Survey ofPollution Sourcesinto the Lake Texcoco Ecological Park, Central México.ISI-Proceedings of International Conference on Chemical Engineering and Applications*, 23:5-9.

[2] Guardado-Lacaba, R., A. Kempena y A. Martínez. 2000. Cartografía y evaluación del impacto geoambiental a través de unsistema de información geográfica. *Revista Cubana de Minería y Geología* XVI (3-4): 23-31.

[3] Ramos, J. A., Noyola, C y Tapia F.C. 2010. Aquifer vulnerability and groundwater quality in mega cities: case of the Mexico Basin. Environ Earth Sci (2010) 61:1309–1320.

[4] Codd, A. 2000. Cyanobacterial toxins, the perception of water quality, and the prioritisation of eutrophication control. *Ecological Engineering* 16(1): 51-60.

[5] Gutiérrez-Yurrita, P. J. y M.A. López Flores. 2011. Reflexiones iusambientalistas sobre los criterios para proponer espacios naturales protegidos: hacia una nueva categoría de conservación, el Paisaje místico. *Revista Aranzadi de derecho Ambiental,* 20(2):29-48.

[6] Luna, M. L., Beltrán, R. I., Solís, N.A., Hernández, N., Mercado, F., García, J., Catt, A., Olalde, V., Portugal, V. y Dendooven, L. 2000. Chemical and biological characteristics of alkaline saline soils from the former Lake Texcoco as affected by artificial drainage. *Biol Fertil Soils* 32:102–108.

[7] Chávez, M.T. and Huerta, A. 1985. Estudios ecológicos previos a la creaci6n de un refugio de vida silvestre en el ex-lago de Texcoco. *Biósfera* 1 (5): 18-22

[8] Hurtado, S., F. García-Trejo & P. J. Gutiérrez-Yurrita. 2005. Importancia Ecológica De Los Macroinvertebrados Bentónicos de la Subcuenca del Río San Juan, Querétaro, México. *Folia Entomológica Mexicana* 44(3): 271-286.

[9] Muller, G. 1979. Schwermetalle in den Sedimenten des Rheins, Veranderungen seit 1971, Umschau. 79: 778-783.

[10] Stoffers, P., G. P. Glasby, et al. (1986). "Heavy metal pollution in Wellington Harbour." New Zealand Journal of Marine and Freshwater Research 20(3): 495-512.