

Nitrate Removal Efficiency with Hydrophytes of Los Reyes Aztecas Lake Water, México

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Abstract

The study was carried out to evaluate six different hydrophytes which were tested associated by twos: 1) *Lemna gibba* and *Ceratophyllum demersum*, 2) *Berula erecta* and *Lemna gibba*, 3) *Polygonum punctatum* and *Hydrocotyle ranunculoides*, and 4) *Polygonum punctatum* and *Azolla filiculoides*, for the purpose of removing nitrate from the water of Reyes Aztecas Lake, which is located southeast of Mexico City in Tláhuac District, Mexico D.F. The average of removal efficiency was obtained in relation to the different hydrophytes associations based on five sampling stations. The statistical analysis revealed that there were no significant differences among hydrophytes, all show remarkable ability to remove nitrate in water.

Keywords

Bioremediation, Nitrate, Hydrophytes

1. Introduction

The Reyes Aztecas lake is located southeast of Mexico City, in Tláhuac District, (D.F.). This lake constitutes a mirror of water of approximately 1.9 hectares which is formed by several primary canals of more than 50 meters wide and other secondary canals measuring between 10 to 15 meters wide. The water that feeds the lake comes from the treatment plant “Cerro de la Estrella” which is located in Iztapalapa District (1.6 m³/s and 1.2 m³/s). The water arrives to the plant loaded with nitrates in addition to domestic discharges of the population residing near the riverside, generating a high concentration of nitrates [1].

1.1. Nitrates

Nitrates (NO₃) are very soluble salts, derived from nitrogen, which can be found in food and beverages. These are mainly derived from the use of nitrogen fertilizers, animal excrements, discharges of domestic and industrial waste waters, the use of food additives (canned meat and fish), of natural decomposition by microorganisms, of organic nitrogen matter like animal and plant proteins [2].

Nitrates constitute today the main source of diffuse pollution of surface and underground waters; these are water soluble substances which plants need for their development, but if these are found in large quantities they induce an excessive growth of algae and aquatic bush causing water eutrophication. When the algae and the aquatic bush die, they are decomposed by microorganisms, and thus they deplete the oxygen and make it impossible for other living beings to survive. The result is foul-smelling unusable water [3].

1.2. Hydrophytes

Mexico is one of the countries with the greatest biodiversity in the planet. The richness of the Mexican vegetation and flora is also represented in hydrophytes and aquatic plants. Their presence within a diversity of habitats is fundamental in the balance and development of aquatic life for being, in principle, the primary producers of the ecosystem. Their presence, coverage and structure constitute the ecological landscape of the generically called wetlands, and their health allows the conservation of the aquatic ecosystems as a whole [4].

Azolla filiculoides. Lam., belongs to, AZOLLACEAE family, it has free float lifestyle; it's abundant in Valley of Mexico; common name aquatic fern; uses, forage and green manure [4].

Berula erecta. (Huds.) Cov., belongs to APIACEAE family, it has rooted pop lifestyle; it's abundant in Valley of Mexico; common name aquatic berro; uses, medicinal, edible and forage [4].

Ceratophyllum demersum L., belongs to CERATOPHYLLACEAE family, it has free underwater lifestyle, it's low in Valley of Mexico; common name foxtail; uses, green manure and ornamental aquarium [4].

Hydrocotyle ranunculoides L., belongs to APIACEAE family, it has rooted pop lifestyle; it's abundant in Valley of Mexico; common name navel of Venus; uses, forage [4].

Lemna gibba L., belongs to LEMNACEAE family, it has free float lifestyle; it's abundant in Valley of Mexico; common name aquatic lentil; uses, forage and green manure [4].

Polygonum punctatum Ell., belongs to POLYGONACEAE family, it has rooted pop lifestyle; it's abundant in Valley of Mexico; common name aquatic chili; uses, forage [4].

1.3. Background

The rise of biological research related with water treatments using hydrophytes has opened a vast field filled with hope due to its low cost and simple infrastructure [5].

Furthermore, their prominent ability of nutrient assimilation and the creation of favorable conditions for the decomposition of organic matter are widely known [6]-[9].

These characteristics promote hydrophytes in the use of wastewater treatment systems [10].

Lemna gibba, *Myriophyllum* and *Eichhornia crassipes* have been used separately for the removal of nitrates from waste water with the following results: an efficiency rate of 32%, 82% and 0% respectively [11].

In another study, three hydrophytes were used for the removal of nitrates from domestic waste waters obtaining the following results: *Eichhornia crassipes*, had an efficiency rate of 15.38%, *Lemna gibba* 31.25% and *Azolla filiculoides* 22.22% [12].

In another research is working with three aquatic plants: *Eichhornia crassipes*, *Pistia stratiotes* and *Lemna gibba*, for the removal of nitrates from waste water supplied by a waste digester fed by excrements from bovine cattle, obtaining the following results: an efficiency rate of 70%, 73% and 99% respectively [13].

Campanella *et al.* 2005 used *Eichhornia crassipes* for the removal of nitrates originated from a waste pipe located in a metallurgical industrial plant Bahco Argentina S.A. in the city of Santo Tomé, obtaining a removal efficiency rate of 50% [14].

Núñez *et al.* 2007, used *Lemna sp* and *Typha dominguensis* for the removal of nitrates from waste waters obtaining the following results: an efficiency rate of 18% and 36% respectively [15].

The objective of this study is to prove the efficiency to remove nitrates from water with six different hydrophytes associated by twos, at five different stations of the Los Reyes Aztecas lake in Tláhuac District.

2. Materials and Methods

2.1. Area of Study

Reyes Aztecas Lake is located in the San Pedro neighborhood, in Tláhuac District, which in turn, is located southeast of Mexico City, within the Mexico Basin, bordering to the north and northeast with the Iztapalapa District, to the south with Milpa Alta, to the east and southeast with the Valle de Chalco municipality in the State of Mexico, and finally it is located west of Xochimilco District [16]. It is located between the coordinates 19°19'2.3" North and 99°00'55.5" West, the approximate altitude is 2240 m.a.s.l., the climate is temperate with humidity variations (See **Figure 1**) [17].

2.2. Water and Hydrophytes Sampling

A total of five sampling sites were established; station 1 at the pier, station 2 secondary canal (near houses, Cisneros street), station 3 bovine cattle breeding area, station 4 near a spring and station 5 in the water spillway from the Cerro de la Estrella treatment plant; these are the places where water samples were taken during the months of June 2011, September 2012, October 2012 and November 2012, the samples were carried to the laboratory in plastic bottles inside an ice cooler.

The samples of hydrophytes: *Azolla filiculoides*, *Berula erecta*, *Ceratophyllum demersum*, *Hydrocotyle ranunculoides*, *Lemna gibba* and *Polygonum punctatum*, were collected manually in the secondary canals of the Reyes Aztecas Lake, these were placed inside a plastic ice cooler in order to be carried to the laboratory.

The bioassay was carried out in a controlled light laboratory with a light/darkness 12/12 photoperiod on eight plastic trays. For each station, four associations were used which were made in triplicate, a witness without plants was used for every station and every association. The trays had the following size: 30.5 cm long, 15.5 cm wide and 10 cm high, to which 2000 ml of water from the lake were added. The four associations that were used were: *Lemna gibba* and *Ceratophyllum demersum*, *Berula erecta* and *Lemna gibba*, *Polygonum punctatum* and *Hydrocotyle ranunculoides*, *Polygonum punctatum* and *Azolla filiculoides*.

At the beginning of the bioassay the nitrogen was measured in the form of nitrates by the method of Cataldo, [18] these were kept for a period of fifteen days, after which this determination was repeated. The efficiency was obtained in relation percentages of the initial values minus the final values divided by the initial values times 100.

2.3. Statistical Analysis

The bioassay was made with 3 replications for each treatment and the data were analyzed with a coefficient of variation (C.V.) and analysis of variance method (ANOVA) from Number Cruncher Statistical System (NCSS version 2001) at 5% significant rate.

3. Results and Discussion

Table 1 shows average nitrates of five sampling sites, asociations hydrophytes, removal efficiency and coefficient of variation with respect each sampling site, where the number 3 display the highest homogeneity and the highest heterogeneity is displayed by number 5.

According to the ANOVA analysis, the average of removal efficiency in relation to the different hydrophyte associations do not display significant differences $F_{2,16} = 0.21$; ($P > 0.05$). See **Figure 2**.

On the other hand, the average of removal efficiency with relation to the five stations do not display significant differences according to $F_{2,16} = 0.21$; ($P > 0.05$), although it was observed that station 1 has only a 44.25% of removal efficiency and all the other stations more than 70%. See **Figure 3**.

Table 2 shows the coefficient of variation with respect to the associations, where the association *Lemna* and *Ceratophyllum* display the highest homogeneity and the highest heterogeneity is displayed by *Polygonum* and *Hydrocotyle*.

Comparing previous works regarding *Lemna* we obtained an average of removal efficiency of 71.8% associated with *Ceratophyllum* and 77% associated with *Berula*, this value is higher than the one in the [11] reports, who obtained 32%; [12] obtained 31.25% and [15] 18%. But the value is lower to that published by [13] who obtained 99%. In this work *Azolla* presented a removal efficiency of 67.2% associated to *Polygonum*, a much



Figure 1. Localization of Reyes Aztecas Lake in Tláhuac District, Distrito Federal, México.

Table 1. NO₃ concentration by initial and final sampling site; nitrate removal efficiency and coefficient of variation (C.V.).

SAMPLING SITES	ASSOCIATIONS (Hydrophytes)	INITIAL CONCENTRACIÓN NO ₃ (mg/L)	FINAL CONCENTRACION NO ₃ (mg/L)	REMOVAL EFFICIENCY (%)	C.V. %
1	<i>Lemna—Ceratophyllum</i>	2.2	1.3	38	38.3
	<i>Berula—Lemna</i>	2.2	1.8	17	
	<i>Polygonum—Hydrocotyle</i>	2.2	1.0	54	
	<i>Polygonum—Azolla</i>	2.2	0.7	68	
2	<i>Lemna—Ceratophyllum</i>	9.4	1.2	87	86.2
	<i>Berula—Lemna</i>	9.4	0.2	98	
	<i>Polygonum—Hydrocotyle</i>	9.4	3.5	63	
	<i>Polygonum—Azolla</i>	9.4	1.6	83	
3	<i>Lemna—Ceratophyllum</i>	14.5	1.4	90	34.5
	<i>Berula—Lemna</i>	14.5	0.9	94	
	<i>Polygonum—Hydrocotyle</i>	14.5	1.4	90	
	<i>Polygonum—Azolla</i>	14.5	0.6	96	
4	<i>Lemna—Ceratophyllum</i>	5.5	2.6	53	62.0
	<i>Berula—Lemna</i>	5.5	1.2	78	
	<i>Polygonum—Hydrocotyle</i>	5.5	1.1	80	
	<i>Polygonum—Azolla</i>	5.5	0.6	89	
5	<i>Lemna—Ceratophyllum</i>	24.5	2.1	91	103.5
	<i>Berula—Lemna</i>	24.5	0.4	98	
	<i>Polygonum—Hydrocotyle</i>	24.5	8.5	65	
	<i>Polygonum—Azolla</i>	24.5	2.6	89	

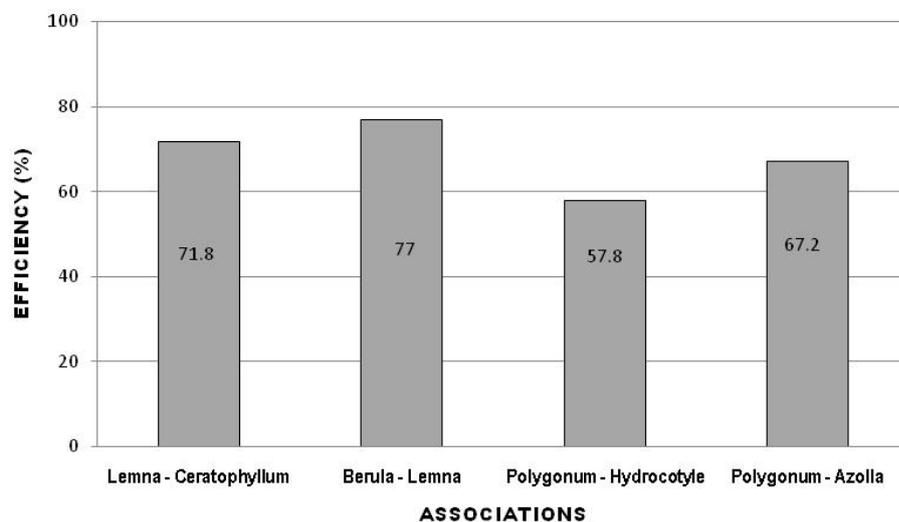


Figure 2. Removal efficiency (%) vs hydrophytes associations.

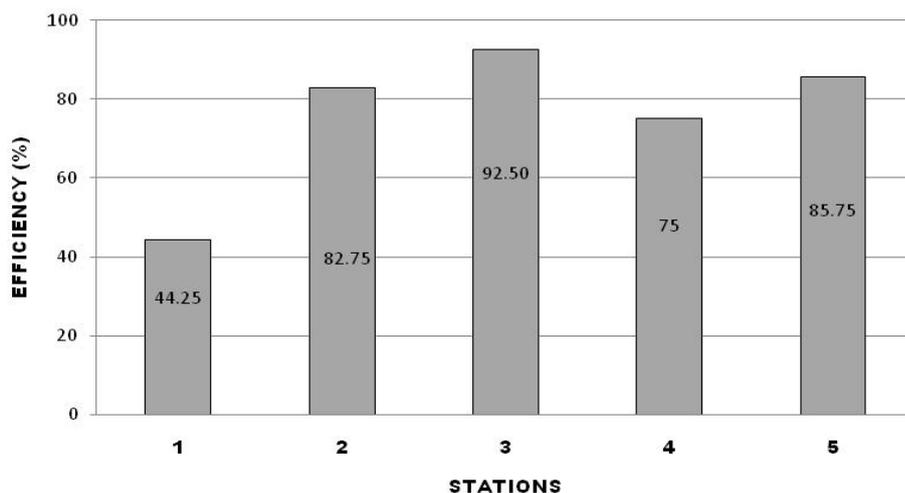


Figure 3. Removal efficiency (%) vs sampling sites.

Table 2. Coefficient of variation with respect different associations.

HYDROPHYTES ASSOCIATIONS	C.V. %
<i>Polygonum—Hydrocotyle</i>	102.7
<i>Polygonum—Azolla</i>	71.3
<i>Berula—Lemna</i>	71.1
<i>Lemna—Ceratophyllum</i>	34.8

higher value than the 22.22% reported [12].

4. Conclusion

In this way the study leads us to conclude that the six different species hydrophytes associated by twos evaluated here all show same remarkable ability to remove nitrate in water, at five different stations of Los Reyes Aztecas Lake, Tláhuac, D.F., supporting highly the use of hydrophytes in domestic waste water treatment since it is cheap and environmental friendly.

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