INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 4, No. 12, p. 229-236, 2014

RESEARCH PAPER OPEN ACCESS

Autecology of *Avicennia marina* at Nayband National Marine Park

Esmaeil Kouhgardi[1*], Mehrdad Akbarzadeh[2], Abdolhamid Mousavi[3]

[1]*Forestry Department, Bushehr Branch, Islamic Azad University, Bushehr, Iran*

[2]*Agronomy Department, Miyaneh Branch, Islamic Azad University, Miyaneh, Iran*

[3]*Rangeland Department, Arsanjan Branch, Islamic Azad University, Arsanjan, Iran*

Key words: Grey mangrove, Nayband, sediments, *Avicennia marian*, autecology.

http://dx.doi.org/10.12692/ijb/4.12.229-236 Article published on June 28, 2014

Abstract

In order to study autecology of *Avicennia marina* this research has been conducted in Nayband National Marine Park in South of Iran. Fifteen stations have determined at random and three repetitions have been considered at each station and then quantitative and qualitative parameters of the stand have been studied. In order to determine the relation among physical and chemical parameters of water and soil as well as heavy metals of sediments, samples of water and sediments have been taken from the location of stations. The results have revealed that vegetation in most zones enjoys desirable conditions in view of qualitative parameters except stations 6 and 7. There existed positive correlation only between average diameter and acidity and also a negative significant correlation between pH of water and qualitative characteristics of trees ($P<0.05$). There is no significant correlation between mercury and chromium and basic qualitative characteristics. Nickel has a negative significant correlation with average height and average basic diameter of trees. There is also a negative significant correlation between vanadium and all basal characteristics of grey mangrove. Similar conditions went the same with lead in such a way as there is a negative significant correlation between lead and average diameter of crown, number of trees, average height and average basal diameter ($p<0.05$). On a whole, one may say quantity of lime, pH of water, completeness of tide and quantity of vanadium and lead has an effective role on growth and quality of the forest stand in the study area.

* **Corresponding Author:** Esmaeil Kouhgardi ✉ kouhgardi@yahoo.com

Introduction

Plants are the most important resources, which exist in ecosystem and as primary producers; they play a prominent role in life of other living beings. Role of plants and balance in natural ecosystem and knowledge of relations between plants and natural elements as well as other living beings is of necessary for preserving stability and consistency in ecosystem. Walters (1997) is of this opinion that Mangrove forests are formed at three climates.

A . Tropical regions at north latitude of 10-15 degrees

B. Tropical regions on the north and south sides of equator, with rainfall in summer and are located at north latitude of 25-30 degrees. Parts of the said forests are located in the said regions at semi-warm-dry zones.

Mangrove populations of Iran consist of *Rhizophora mucronata* Lam. and *Avicennia marina* Forssk (Grey Mangrove), comprising purse, constant and semi-epoch forest regions.

Main regions for dispersion of the said species start from Oman Sea and end at Nayband Gulf in the west side of Persian Gulf.

Economic importance of grey mangrove lies in its direct and indirect values. Major part of its application is because of its head branches, which are cut and used as livestock feed to a great quantity (Kouhgardi *et al.,* 2006). Indirect values of grey mangrove are introduced as protection of coats against different erosions, environmental protection, preserving genetic reserves, decrease of energy of waves, destructive power of storm and aquatic farming regions. In the regions where grey mangrove is located beside rivers, they prevent river erosion (Davari *et al.,* 2010).

The aim of this research is to conduct autecology of *Avicennia marina* (Grey Mangrove) in Mangrove forests of Nayband National Marine Park and to study water and soil characteristics of growth place for determination of optimized conditions for development of the said species in the said zone, subject of study and to study type ad quantity of use of Mangrove forests of Nayband National Marine Park by people and local organizations.

Materials and methods

Study area

Mangroves forests of Bushehr Province are parts of coastal area of Persian Gulf. Growth place, subject of study, is located at 27º 27' of north latitude and 52 º 39' of east longitude, at ultimate area of the eastern side of Bushehr Province, adjacent to joint border of Hormozgan Province.

Sampling

In consideration of area, extension and form of growth place, 15 stations have been determined for measurement of quantitative and qualitative parameters of vegetation, physical and chemical properties of water and soil and measurement of heavy metals in sediments in the regions, subject of study based on random method.

The reason for choosing random method in the said zone is that vegetation of plants is in compiled form and there are no continuous forests in the said zone. Relying on form and type of vegetation in the said zone, stations have been chosen at random. First, respective points have been designated on the map and then, they have been positioned in the zone, subject of study. Nayband Gulf has two estuaries of Asaluyeh and Basatin. Seven stations have been positioned in Basatin estuary and the rest of eight stations in Asaluyeh estuary. At each station, three plots have been designated for sampling in order to study characteristics of vegetation and three points for sampling of water and soil at random. At each station, number of existing trees of each plot, diameter of crown, basic average height, diameter of trunk, regenerating status, freshness and health of trees, desiccation and pests of trees have been studied. Samplings in afternoon were conducted when sea was in tide state. However, vegetation bed was completely marshy. Respective samples taken

have been transferred to laboratory and chemical and physical properties of water and soil have been determined. In order to study quantity of heavy metals, torch-operated atomic absorptive spectrometer has been used.

Statistical analysis

Regarding each parameters, subject of study, average, minimum, maximum, standard deviation, variance, skewness and elongation of each plot have been calculated. Unilateral variance analysis (ANOVA) has been used in order to compare averages and Tukey-HSD test at reliability level of 95% has been used in order to determine difference of parameters. Correlation among parameters has been determined using Pearson Correlation Coefficient.

Results

Respective results, obtained from this research consist of several main parts from among which we may point out qualitative and quantitative characteristics of stand of Mangrove, physical and chemical properties of water and soil and existing heavy metals in the sediments of the said zone.

Table 1. Qualitative parameters of stand of grey mangrove in stations, subject of this study.

Station	Average basal diameter (cm)	Average diameter of crown (cm)	Average height of tree (cm)
1	7.29±0.6g	135.8±10.5b	117.5±5.6b
2	5.1±1.6e	91.8±48.2a	78.0±15.8a
3	3.7±0.58cd	142.0±38.6bc	128.3±36.2b
4	8.4±6.6h	131.7±73.8b	130.0±65.6b
5	6.2±0.76f	157.0±24.3bc	184.0±14.4d
6	4.8±3.6de	133.4±51.3b	153.3±47.3c
7	7.8±2.9gh	234.0±43.4e	286.3±34.1f
8	2.3±0.9b	249.0±89.2e	189.3±31.2
9	3.1±0.9c	355.3±210.7g	310±210.5g
10	4.3±0.8d	309.6±103.2f	350.7±56.9h
11	4.5±1.3d	435.0±56.3i	486.3±12.1
12	4.4±0.5d	410.0±95.4h	460.3±53.1ij
13	3.2±0.5c	396.6±15.3h	440±36.3i
14	1.6±0.81a	163.4±37.8c	305.0±231.1fg
15	1.6±0.5a	150.0±55.0bc	230.7±60.2e

*Similar letters in each column indicate no significant difference among stations.

Stand characteristics

From among qualitative indices of the stand, due to unique characteristics of ecosystem, respective parameters, which have been measured, are namely freshness, regenerating, pneumatophore, pest and desiccation. Relying results, it has been revealed that in all six stations, the entire qualitative parameters have been decreased by 50% and in station 7, the same is decreased by about 100%. In other stations, the same enjoys desirable conditions.

Relying on studies conducted, size of plot of this research was 5 x 5 m (circular form with a radius of 5 m), Respective particulars have been studied and measured in all 15 stations (Three repetitions in each station), (Table 1).

Site conditions

Results obtained from analysis of physical and chemical properties of soil in different stations are given in Table 2. The said findings reveal that there is no significant different in value of pH, percentage of lime and phosphorus among different research stations. Some other parameters have shown limited changes in different stations.

Data analysis

Results obtained from correlation between qualitative characteristics of stand and physical and chemical characteristics of sediment have been given in Table 3. As it has been indicated, there is no significant correlation among qualitative variables of stand including basic average height, average diameter of

crown, basic average diameter and number of trees and electrical conduction parameters, percentage of saturation, organics, total nitrogen, quantity of sand and silt, as well as clay ($p<0.05$).

Study of correlation between characteristics of plants and water properties reveal that there is a negative significant correlation between pH of water and all variables of trees subject of study ($p<.05$). This correlation is negative and really significant due to saltiness and average diameter of stem and number of trees ($p<0.05$). No correlation has been observed between average height of tree and electrical conduction of water although average diameter of crown and basal diameter has had a negative and significant correlation with electrical conduction ($p<0.05$). Also, electrical conduction has a negative and very significant correlation with number of trees ($p<0.05$) in such a way as number of trees has decreased upon increase of electrical conduction in a significant way (Table 4).

Table 2. Physical and chemical parameters of soil in stations.

station	Soil texture	Clay %	Silt %	Sand %	K P.P.M	P P.P.M	N %	Lime %T.N.V	S.P %	pH	EC*103
1	S-L	15.4±1.3	8.0±1.1a	76.6±8.2c	240±24a	1.9±0.2	0.0012a	82.4±4.3	34.5±6.1a	8.1±0.6	39.4±2.3ab
2	L	17.4±3.1	37.8±6.1b	44.8±2.4b	280±34b	1.8±0.3	-	81.5±2.0	37.8±6.2ab	8.1±0.4	47.7±3.4bc
3	S-L	15.4±2.8	2.0±0.1a	84.8±4.4d	200±35a	1.2±0.3	-	81.6±2.2	33.9±4.8a	8.0±0.3	35.4±1.6a
4	S-L	15.4±2.7	5.8±0.6a	78.8±6.7c	210±74	1.5±0.2	0.01b	82.4±7.6	33.9±3.1a	8.1±0.2	48.9±4.2c
5	S-L	17.4±2.7	5.9±0.4a	76.7±3.9c	280±28b	1.4±0.1	0.01b	81.5±1.4	34.2±4.5a	8.1±0.2	48.7±3.6bc
6	S-L	15.4±2.2	8/8±0.7a	75.8±4.3c	270±29ab	1.2±0.2	0.01b	81.5±6.2	34.5±4.4a	8.1±0.3	48.8±3.3bc
7	S-L	15.4±2.3	6.0±0.5a	78.6±8.6c	210±271a	1.2±0.1	0.01b	82.4±9.3	34.4±8.1a	8.1±0.4	48.8±5.3bc
8	S-L	15.4±3.1	9.0±1.2a	75.6±1.4c	210±29a	1.1±0.2	-	81.3±7.2	34.3±2.7ab	8.0±0.2	49.9±6.1c
9	L	17.4±3.8	43.8±5.6bc	38.8±4.7b	440±35c	1.1±0.2	-	81.4±6.3	41.2±3.6ab	8.1±0.3	48.5±7.2bc
10	L	15.4±2.7	46.8±3.4bc	38.8±4.9b	420±64c	1.3±0.3	-	81.2±5.0	41.3±8.2ab	8.0±0.4	48.6±1.7bc
11	L	17.4±3.5	43.8±3.4bc	38.8±5.7b	420±70c	1.2±0.1	0.01b	81.2±9.6	42.2±5.3ab	8.2±0.5	48.6±4.3bc
12	Si-L	15.4±2.6	59.8±7.4e	24.8±2.9a	440±24c	1.2±0.1	0.01b	81.5±7.5	49.2±1.4ab	8.1±0.3	42.6±5.1ab
13	Si-L	15.4±2.1	58.9±4.6e	25.7±5.4a	560±43d	1.2±0.1	0.01b	88.2±1.8	51.3±6.8b	8.0±0.6	41.9±4.4
14	Si-L	17.4±3.7	58.0±6.6de	24.6±4.3a	540±36d	1.3±0.2	0.01b	87.3±1.4	52.4±7.5b	8.0±0.4	42.5±2.1ab
15	Si-L	15.4±3.4	59.8±7/0e	24.8±3.1a	560±67d	1.3±0.1	0.01b	87.2±3.7	52.5±2.3b	8.0±0.3	42.6±1.9ab

*Similar letters in each column indicate no significant difference among stations.

The study of the relation between heavy metals and characteristics of plants reveals that there is no significant correlation between value of mercury, chrome and cadmium and average height of tree, average diameter of crown and number of trees (Table 4). Instead, there is a negative and significant correlation between value of nickel and average height of tree and average diameter of stem. However, no correlation between nickel and average diameter of crown and number of trees has been proven. Also, there is a negative and significant correlation between vanadium and all characteristics of trees of grey mangrove. Similar conditions were true about lead in such a way as there has been a negative and significant correlation between value of lead and average diameter of crown and number of trees ($p<0.05$) and a negative and really significant correlation between the same and average height of tree and average diameter of tree ($p<0.05$).

The role of human

Fundamentally, with respect to finding background for joint development of natural resources, awareness about use of natural resources by native residents, indicating an interactive relation between people and nature is of great importance. According to findings, presented in Table 6, the mot use of Mangrove forests is for livestock feed (57%) and fuel (49%) and other different uses such as timber of Mangrove trees is used in development of rest areas for animals, windbreak and the ones.

Discussion

Relying on results obtained from this research and statistical analyses conducted in this regard, we may come up with this conclusion that there is no significant correlation between qualitative variables of stand including average height of tree, average diameter of crown, average diameter of stem, and number of trees and electrical conduction parameters, percentage of saturation, quantity of organics, total nitrogen, and quantity of sand and silt and clay.

Table 3. Correlation between trees characteristics and physical and chemical properties of soil.

Parameter	Clay %	Silt %	Sand %	K P.P.M	P P.P.M	N %	OC	Lime %T.N.V	S.P %	pH	EC*10³
Average height of tree	0.20	0.03	-0.18	0.29	0.76**	0.27	0.17	0.61*	0.02	-0.21	-0.59
Average diameter of crown	0.16	0.07	-0.40	0.47*	0.91**	0.31	0.06	0.35	0.04	-0.45*	0.03
Average diameter of stem	0.25	0.17	-0.29	0.36	0.83**	0.20	0.19	0.57*	0.03	-0.31	-0.28
Number of trees	0.00	-0.05	0.02	0.11	0.45*	0/07	0.06	0.07	-0.17	-0.07	0.01

* Significant difference at 5%

** Significant difference at 1%.

Thus, one may say that texture of soil, quantity of organics, and electrical conduction of sediments has no slight effect on quantity of stand of grey mangrove in Nayband Zone. On the other hand, corresponding results show that there is a significant different in morphological characteristics of trees among different stations. This may be due to such reason as adjacency of Basatin estuary to the factories, established in the said zone, affecting morphological characteristics of trees. For example, diameter of trunk has decreased and height of trees has increased. Since the said estuary is adjacent to city of Asaluyeh, pasture of local livestock and entry of wastewater in the said estuary are more in the said zone, affecting morphological characteristics of the same. Moreover, relying on results obtained from comparing the two estuary of Asaluyeh and Basatin, Asaluyeh estuary enjoys certain zones where grey mangrove, Mangrove trees are made in form of plantation, with low height. This may be among reasons for significant difference among different stations. This result has also been obtained by Davari *et al.,* (2010) as well. According to the said research, they came up with this conclusion that wastewaters may affect morphology of species.

Table 4. Correlation between characteristics of trees and physical and chemical properties of water.

	EC(µS/m)	Salinity (%)	pH
Average height of tree	57.7±3.4a	48±3ab	7.35±0.21ab
Average diameter of crown	72.9±5.1b	51±6b	7.53±0.18ab
Average diameter of stem	60.3±6.2a	41±4a	7.22±0.22a

*Similar letters in each column indicate no significant difference among parameters.

Relying on results obtained, only correlation was related to average diameter of crown, which had a negative correlation with value of pH In other words, increase of pH may cause decrease average diameter of crown, leading to thinness of plant mass because the soil of the said zone is neutral to weak basic in such a way as the highest value of pH doesn't exceed 7.9. Relying on results, Station No 6 has the highest pH due to shortage of water at the said Station and low movement of water, leading to increase of saltiness and pH. This is mainly because of decrease of movement and transfer of water, which results in more evaporation and raise of concentration of existing elements of water. This has led to thinness of plant mass and in long-term may result in decrease of freshness and in case of consistency of such

conditions as described above, it may lead to desiccation of part of plant body or the entire plant mass (El-Amri *et al.,* 1998). Concerning the fact that electrical conduction is increased due to increase of salts of soil, we may come up with this conclusion that the said salts are increased due to turbidity of water by animals or due to activities done by humans (Tam *et al.,* 1996) and eventually, electrical conduction is increased. This phenomenon leads to rise of EC and decrease of average diameter of stem and basal diameter of the species in its turn, confirming the results of Burchett *et al.,* (2006) accordingly.

Table 5. Correlation between characteristics of trees and heavy metals.

Parameter	Cadmium	Mercury	Vanadium	Chromium	Nickel	Lead
Average height of tree	0.12	-0.13	0.54*	-0.17	-0.65*	-0.76**
Average diameter of crown	0.10	-0.07	-0.07*	-0.13	-0.23	-0.52**
Average diameter of stem	0.13	-0.02**	-0.02**	-0.15	-0.49*	0.81**
Number of trees	-0.11	-0.14	-0.14*	-0.07	-0.28	-0.59*

* Significant difference at 5%.

** Significant difference at 1%.

The highest value of correlation from among characteristics, subject of study, has been observed in phosphorus and characteristics of trees in such a way as average height and average diameter of tree has shown high significant correlation with concentration of phosphorus in sediments and eventually, we may come up with this conclusion that shortage of phosphorus has a noticeable effect on characteristics and growth of grey mangrove. This has also been confirmed by Erfani *et al.,* (2008) as well. Only the correlation between number of trees and chemical properties of soil is also related to phosphorus, which has a significant correlation with each other. Thus, we may come up with this conclusion that in any area of Nayband Zone where conversion process of organics to non-organics and analysis of materials (especially with respect to the element of phosphorus) is done more completely, it may lead to increase of height of trees and that of their diameter. This is consistent with the research of Erfani *et al.,* (2008), with respect to the element of phosphorus.

Table 6. Use of Mangrove Forests by People (Kouhgardi *et al*, 2006).

Kind of use	Frequency *	Percentage
Livestock feed	68	57
Fuel	59	49
Household and pharmaceutical consumptions	6	5
Others	38	31.7
No reply	3	2.5

* Some participants have replied more than one item.

Relying on results obtained, high saltines has caused concentration of salt in pneumatophore of grey mangrove because of which breath of the said tree is done difficultly. Although *Avicennia marina* is an optional tree that likes saltiness, threshold of saltiness tolerance of the plant has a certain range (up to 15.4 psu) (Tusharbhai Patel *et al.,* 2010). When saltiness exceeds tolerance threshold of the plant, the glands of root of the said plant is not able to treat water, removing its saltiness, leading to desiccation of the said plant. This has been indicated in the research of Burchett *et al.,* (2006) and Anderson *et al.,* (1988),

which had studied the relations between parameters of growth and breath of root under different saltiness conditions in the shrub of grey mangrove. They have also come up with this conclusion that at saltiness higher than 25%, Oxygen absorption by the plant is decreased accordingly.

The study of the relationship between heavy metals and characteristics of plants reveal that upon increase of lead and vanadium, morphological characteristics of the plant will change, leading to weakness of the species. It means that diameter of trunk, basal diameter and crown diameter are decreased upon increase of the said two metals. Relying on the said results, we may come up with this conclusion that mercury, chrome and cadmium have no slight effect on growth characteristics of the plant. In a research conducted by Davari *et al.,* (2010), they have also come up with this conclusion that quantity of lead and vanadium exceeds global standards in Nayband Gulf. One of the reasons for such increase in quantity of the said metals in the said Gulf may be related to petrochemical and petroleum activities done in the zone, subject of study. The result of the research of the said researchers (Rabani *et al.,* 2008) is consistent with this research accordingly.

On a whole, study of correlation and evaluation of stations, subject of study, reveals that Basatin estuary is so different from Bidkhoon estuary considering morphological characteristics. However, we may also come up with this conclusion that adjacency of petrochemical equipment only affects morphological characteristics of the said species and it has not much effect on the quality of the said forests (Rabani *et al.,* 2008).

In general, we may state that from among heavy metals, lead, vanadium and nickel have more negative effect and their constant presence in the ecosystem of the said zone shall lead to weakness of vegetation and eventually, decrease of utilization and operation of the said plant. The most important point is that quantity of heavy metals in the said zone are being increased due to contaminations and on the other hand, upon change of no access of seawater by Mangrove plants, as it has been analyzed, it has resulted in increase of saltiness, electrical conduction and acidity and increase of the said two phenomena jointly i.e. increase of entry of heavy metals, on the one hand and increase of saltiness and electrical conduction and acidity of water, on the other hand, endanger conditions for long-term survival of the said plant (Nirmal Kumar *et al.,* 2011). According to the results of this research, one may point out use of native people according to which livestock feed, fuel consumptions, household consumptions and other items may be added to reasons for inconsistency and jeopardizing the said valuable forests (Kouhgardi *et al.,* 2006).

From among other elements, which are effective in growing place, subject of study, we may point out drought in the recent years, construction of bridges and roads, which has closed passage of natural tide of sea. Moreover, shortage of sufficient human resources for protection of the said stand is evident.

Relying on results of this research, we may state that due to marshy growth place, generic breeding by the use of seed is done slowly. However, non-generic breeding of the said species is done more rapidly by the use of shrubs, which are grown on their stem or air root in such a way as herein this research, three shrubs have been calculated on average around each tree. Thus, we may say that plant cultivation is the best method for regenerating of the said species (Ochieng *et al.,* 2002).

References

Andersen F, Kristensen E. 1988. Oxygen microgradients in the rhizosphere of the mangrove *Avicennia marina*. Journal of Marine Ecology **44,** 201-204.

Buajan S, Pumijumnong N. 2010. Distribution of heavy metals in mangrove sediment at the Tha Chin Estuary, Samut, Sakhon province, Thailand. Journal of Environmental Research **32,** 61-77.

Burchett MD, Field CD, Pulkownik A. 2006. Salinity, growth and root respiration in the grey mangrove, Avicennia marina. Physiologia Plantarum **60,** 113 – 118. http://dx.doi.org/10.1111/j.13993054.1984.tb04549.x

Davari A, Danekar A, Khorasani N, Javanshir A. 2010. Aggergation of heavy metals in bottom, leaf and root of *Avicennia marina* in Bushehr province. Iranian journal of Natural Resources **63,** 377-367.

El-Amri M. 1998. Population structure, demography and life tables of *Avicennia marina* (Forssk.) at sites on the eastern and western coasts of the United Arab Emirates. Journal of Marine and Freshwater Research **49,** 303-308. http://dx.doi.org/10.1071/MF97144.

El-Khouly A, Khedr A. 2007. Zonation pattern of *Avicennia marina* and *Rhizophora mucronata* along the Red Sea coast, Egypt. World Applied Sciences Journal **2,** 283-288.

Erfani M, Danekar A, Ardakani T. 2008. Investigation of relationship of nutrients in branches and sediments of mangrove forests of Guater bay. Iranian journal of Forests and Rangelands **6,** 118-137.

Kouhgardi E, Akbarzadeh M. 2011. Local people perspectives about effects on degradation of Mangrove forests, case study; Nayband National Marine Park, Iran. IUFRO Conference; Competence development for forestry, Germany.

Nirmal Kumar I, Ravi Sajish P, Nirmal R, Basil G, Shailendra V. 2011. An Assessment of the Accumulation Potential of Pb, Zn and Cd by *Avicennia marina* (Forssk.) Vierh. in Vamleshwar Mangroves, Gujarat, India. Notulae Scientia Biologicae **3,** 36-40.

Macfarlane GR, pulkownik A, Burchett MD. 2003. Accumulation and distribution of heavy metals in the grey mangrove, *Avicennia marina* (Forsk.) Vierh. Biological indication potential. Environmental Pollution **123,** 139-151. http://dx.doi.org/101016/S0269-7491(02)00342-1

Ochieng C, Erftemeijer P. 2002. Phenology, litterfall and nutrient resorption in *Avicennia marina* (Forssk.) Vierh in Gazi Bay, Kenya. Journal of Trees **16,** 167-171. http://dx.doi.org/101007/s00468-001-0146-2.

Rabani M, Jafarabadi A, Mehrdad-Sharif A. 2008. Measurement of heavy metals (Nickel, Lead and Mercury) pollution in sediments of the Persian Gulf in Asalouyeh area. Journal of Exploration and Analysis **51,** 53-57.

Rasool F, Saifullah SM. 2005. A new technique for growing the Grey Mangrove *Avicennia marina* (Forssk.) Vierh in the field. Pakistan Journal of Botany **37,** 969-972.

Shriadah MA. 1999. Heavy Metals in Mangrove Sediments of the United Arab Emirates Shoreline (Persian Gulf). Water, Air, & Soil Pollution **116,** 523-534. http://dx.doi.org/10.1023/A:1005139020681.

Tam NF, Wong YS. 1996. Retention and distribution of heavy metals in mangrove soils receiving wastewater. Journal of Environmental Pollution **94,** 283-91. http://dx.doi.org/101016/S0269-7491(96)00115-7

Tusharbhai Patel N, Gupta A. Nath Pandey A. 2010. Salinity tolerance of *Avicennia marina* (Forssk.) from Gujarat coasts of India. Journal of Aquatic Botany **93,** 9-16. http://dx.doi.org/10.1016/jaquabot.2010.02.002.

Walters BB. 1997. Human ecological questions for tropical restoration: experiences from planting native upland forest and coastal mangrove trees in the Philippines. Forest Ecology and Management **99,** 275-290. http://dx.doi.org/101016/S0378-1127(97)00211-9.