

Contamination of heavy metals in mangroves: A comparison between Caño Martín Peña and Guánica.

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ABSTRACT- Mangroves are important ecosystems because they serve as natural barriers for coastal erosion, host different animal species, and purify water by absorbing pollutants. However, the deforestation, sudden flooding and the exponential increase of population and industrialization had greatly affected the mangroves and their ability of purifying water. Previous researches have demonstrated that contamination of heavy metals in mangroves decrease their chlorophyll levels. The purpose of this project was to compare two different sites of mangroves and how heavy metals contamination has affected them. The images utilized were obtained from IKONOS sensor to later measure the Normalized Difference Vegetation Index (NDVI), and establish a comparison between both sites. Results from this investigation showed that the NDVI was higher for the Guánica (0.56) area than the Caño Martín Peña (0.33). Environmental reports from Caño Martín Peña have demonstrated that heavy metals such as lead and mercury have indeed, affected the water and the mangroves. However, there are no public reports of this topic related to the Guánica area.

Keywords: Mangroves, Heavy metals, NDVI, Caño Martín Peña, Guánica

INTRODUCTION

Mangrove forests are important ecosystems compose of tropical trees that are mainly found in intertidal zones (coastal zones). Mangroves have the ability of surviving in extreme conditions (salinity, polluted water) and purify the water, serve as a natural barrier for coastal erosion, and host different animal species. Mangrove ecosystems have been lately threatened by natural and anthropogenic disturbances such as

storms, rain, aquaculture, aquatic transportation, and industrialization, among others. These disturbances contaminate them and cause physical changes on mangroves. To measure these changes and to monitor vegetation, several techniques such as Remote Sensing have been developed (Kovacs et. al, 2004). Remote Sensing images of the area can be processed to measure differences of chlorophyll levels in mangroves. The excess of heavy metals that are absorbed by them decreases the chlorophyll levels, causing a higher absorption of the red

band than the near-infrared band (Macfarlane and Burchet, 2001).

IKONOS images are effective to use in these types of studies because of their high spatial resolution: 4m in multispectral images, and 1m in panchromatic images. The images can be processed using Normalized Difference Vegetation Index (NDVI) to measure the vegetation healthiness (chlorophyll levels) at Caño Martín Peña, and Cayo Aurora (Guánica).

Study area

This project is focus in two sites: Caño Martín Peña, and Cayo Aurora, Guánica (Fig. 1). The Caño Martín Peña (Fig. 2) area is located in San Juan at the north of Puerto Rico. The mangrove area at this site is exposed to industrialization of the urban area. The second site (Fig. 3) is Cayo Aurora at Guánica, which is located at the south of P.R. Cayo Aurora, also known as Gilligan's Island, is a recreational and touristic area.

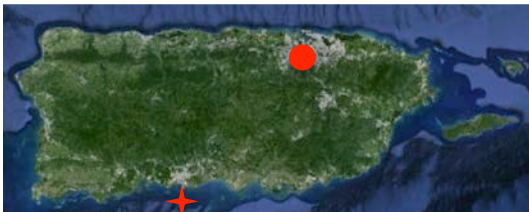


Figure 1. Image of Puerto Rico showing the two study sites. The red dot indicates the location of Caño Martín Peña area, and the red star shows the location of the Guánica mangrove area. Image was obtained from Google Earth 2013.



Figure 2. Image of the Caño de Martín Peña area, which is boxed in red.



Figure 3. Image of the Cayo Aurora area.

METHODOLOGY

The sensor utilized in this study is IKONOS, which has 4 bands: 3 bands in the visible range, and 1 band at the Near-Infrared range. The spatial resolution is: 4m in multispectral images, and 1m in panchromatic images. IKONOS images used in this projects were provided by Prof. Fernando Gilbes from the University of Puerto Rico at Mayagüez. Images were processed using ENVI 5.0.

Preprocessing images

Layer stacking, mosaic, and atmospheric correction

Since IKONOS images were provided by individually bands, they were group together to produce one image. Since both of the sites had multiple images, a mosaic was done in each site in order to generate one image per study area. After the two images were produced, a spatial subset and atmospheric correction was performed in each of the images (dark substract) to eliminate unwanted data.

Processing images

NDVI, Supervised classification, link of all the images

After the images were preprocessed, the Normalized Difference Vegetation Index (NDVI) was calculated. NDVI parameter uses reflectance information of two bands: red and infrared. The equation of this parameter is:

$$NDVI = \frac{NIR - red}{NIR + red}$$

NDVI was calculated using the *Band math* option, where you insert the equation and the program automatically calculates the information. A mask was created for each of the NDVI images to obtain the true values of the vegetation.

Maximum Likelihood supervised classification was performed in order to classified the different components of the images. Four region of interest (ROI) were created for Guánica: land, ocean, reef, and mangroves; and three ROI's were created for Caño Martín Peña: mangroves, city, and water.

NDVI and supervised classification images were linked with the purpose of obtaining an accurate value and classification of the index in each of the site. In each of the images, ten pixels were choose to verify the NDVI value and later on, to calculate the average NDVI value of the sites.

RESULTS

Caño Martín Peña

The average NDVI for this area is approximately 0.33. This value was calculated after choosing ten pixels of the area and then calculating their NDVI average value.

Maximum Likelihood supervised classification

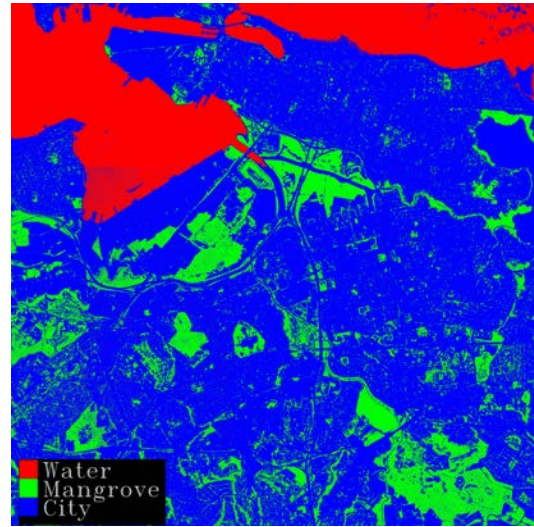


Figure 4. Maximum Likelihood classification of the Caño Martín Peña area. Image was classified in three groups: water, mangrove, and city. According to the image, the city is the most dominant class of the area.

NDVI

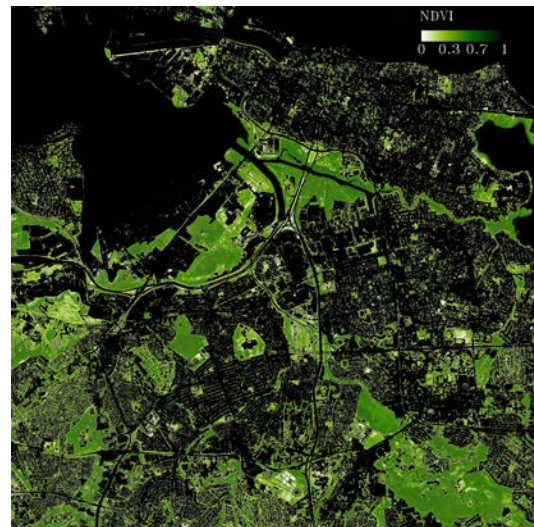


Figure 5. NDVI image for Caño Martín Peña.

Table 1. NDVI values for ten pixels at the mangrove area in Caño Martín Peña

Pixel	Latitude	Longitude	NDVI value
1	18° 26' 20.03" N	66° 5' 5.01" W	0.39
2	18° 26' 17.48" N	66° 4' 58.30" W	0.37
3	18° 26' 5.11" N	66° 4' 18.18" W	0.35
4	18° 26' 2.63" N	66° 3' 55.63" W	0.29
5	18° 25' 51.83" N	66° 3' 39.23" W	0.26
6	18° 25' 44.53" N	66° 5' 14.35" W	0.23
7	18° 24' 27.32" N	66° 4' 8.50" W	0.17
8	18° 26' 43.23" N	66° 2' 22.37" W	0.29
9	18° 26' 19.48" N	66° 4' 49.47" W	0.38
10	18° 26' 16.58" N	66° 4' 45.39" W	0.54

Table 2. NDVI values of ten pixels at Cayo Aurora, Guánica

Pixel	Latitude	Longitude	NDVI value
1	17° 56' 20.03" N	66° 52' 16.23" W	0.23
2	17° 56' 32.34" N	66° 52' 21.36" W	0.41
3	17° 56' 34.78" N	66° 52' 17.36" W	0.59
4	17° 56' 43.60" N	66° 52' 02.19" W	0.77
5	17° 56' 42.69" N	66° 52' 0.18" W	0.40
6	17° 56' 42.69" N	66° 51' 59.85" W	0.74
7	17° 56' 50.02" N	66° 51' 57.65" W	0.53
8	17° 56' 52.13" N	66° 52' 0.92" W	0.53
9	17° 56' 47.31" N	66° 52' 01.42" W	0.85
10	17° 56' 43.57" N	66° 52' 03.38" W	0.51

Guánica

The average NDVI value for the Guánica area is approximately 0.56. This value was calculated after examining ten pixels and then calculating the average value.

Maximum likelihood supervised classification

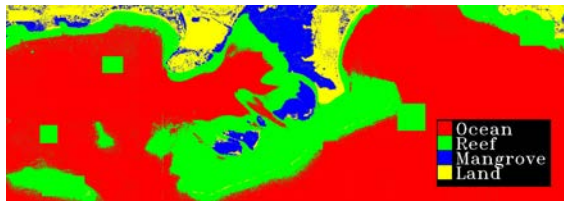


Figure 6. Supervised classification image from Cayo Aurora area (Guánica). The area of study is mainly covered by ocean water and coral reefs.

NDVI



Figure 7. NDVI image of the Guánica area.

DISCUSSION

According to the NDVI calculated from the IKONOS images, the NDVI value for Guánica (0.56) is higher than the NDVI at Caño Martín Peña (0.33). A higher NDVI value indicates that the vegetation on that area is not extremely stressed and their chlorophyll levels are higher. Mangroves that absorb higher quantities of heavy metals decrease the reflectance in the near-infrared area, and the reflectance at the red wavelength increases, causing a lower NDVI value.

Environmental studies at Caño Martín Peña have documented the presence of heavy metals such as lead and mercury in water and sediments near the area (NEPCC, 2007). They have attributed the heavy metals presence to sudden flooding, storms, aquatic transportation and industrialization of the area. However, in the Guánica area there are not recently public studies of the water quality at Cayo Aurora.

CONCLUSION

Results from the NDVI images indicated that Guánica has a higher NDVI value than Caño Martín Peña. Based in this correlation, it is likely to

conclude that Caño Martín Peña is affected by heavy metals contamination. However, to establish a strong correlation, environmental reports and field data is vital. Further research is needed.

area index of a degraded mangrove forest using high spatial resolution satellite data, *Aquatic Botany* 80 p.13–22.

RECOMMENDATIONS

For a stronger correlation between heavy metals contamination and mangroves healthiness, the following is needed:

- Heavy metal analyses and field data.
- Multiple images of the study area from different years and seasons (dry, wet season) are important for monitoring mangroves.
- Aerial photos are needed for mangrove coverage evolution through the years (5, 10, 15 years).

ACKNOWLEDGEMENTS

Special thanks to Prof. Fernando Gilbes for providing the IKONOS images and his guidance in processing images using the ENVI software.

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