SEDIMENT TOXICITY AND HEAVY METAL PHYTOREMEDIATION POTENTIAL OF THREE MANGROVE SPECIES IN PENINSULA LA ESPERANZA, LAS CUCHARRAS MARSH NATURAL RESERVE,CATANO, PUERTO RICO

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ABSTRACT

Anthropogenic activities represent the most common factor for major changes in soil heavy metal (HM) concentrations. Our study site, Península La Esperanza, is part of the San Juan Bay Estuary Watershed, a Wildlife and Natural Reserve located in the north part of Puerto Rico. The mangroves, which are the predominant type of vegetation in the area, can exhibit diverse external and internal mechanisms that allow them to tolerate and function as phytoremediators of HM in surrounding soils. This study was focused in three mangrove species that can be found in La Esperanza: Rhizophora mangle (RM), Laguncularia racemosa (LR) and A. germinans (AG). The 54 samples were selected to be identified, measured concentrations in sediments, in green (C) and Senescent (S) leaves, and study phytoremediation potential as a mitigation alternative for these HM. We collected 20 core samples (4 cores x 5 points) in total (8-Site, 8-Site B, 24 Site C). Sediment samples showed a general tendency of abundance from high to low of Al > B > Cr, Cu, Fe, Mn and Zn. We found a significant difference between all HM and their distribution. Retention percent (RT%) and Bioconcentration factors (BCF) were calculated using HM concentrations found in C. GL AG showed lower RT% for all HM in the 3 sites sampled compared to the other species except for Zn, which could be more used by that species for enzymatic processes. One Way ANOVA for RT% comparing all HM in each site showed p-values of 0.001. GL AG showed high concentration in Gl for As, Cd, Cu, Pb, Ag for Cd, Cu and Zn, while LR in Cd, Cr, Cu and Pb. A higher concentration in Gl could signify that the tree is storing or moving the HM to other parts of the plant and not making them available for other organisms on its leaves. None of the three species seem store to Se but extracting it from sediment and moving to leaves, AG being the one with lower RT% for HM HM. Each species seem to have a threshold concentration range to manage HM efficiently.

INTRODUCTION

The Península La Esperanza as well as the rest of the Cucharillas Marsh is part of the San Juan Bay Estuary Watershed. It is a unique tropical estuary in the Puerto Rico Estuary Program of the US Environmental Protection Agency. In 1979 the Department of Natural and Environmental Resources (DNER) designated the Cucharillas Marsh a Natural Reserve (FR Planning Board, 2008) It has about 126 acres (50 hectares) from which 10 of the acres were donated to the University by the Bacardi industry for scientific research (IFCA, 2004). The Cucharillas Marsh is very a broad wetland ecosystem interconnected with the Bayamon River, the San Juan Estuary and the open Atlantic Ocean. The area has suffered from a high urban development over the year and a significant amount of the marsh was dredged and filled by the Corp of Engineers in the early 30’s. This event was important factor that induced drastic changes in the coastal marsh, fragmenting it, and changing the natural hydrological patterns of the region. The area is highly used by birds, fish and other species and is used for commercial and recreational fishing. Today, most of the mangrove populations occur in the borders of the peninsulas where there are three main species out of four of the mangrove species that exist in P.R. (agavacapitata racemosa, bismarck mangrove, and rhizophora mangle (zebra mangrove). The Península La Esperanza, is part of the San Juan Bay Estuary Watershed.

STUDY SITES

For the study Península La Esperanza was divided in three major areas:
- A) close to the urban community (green leaves and senescent leaves)
- B) inside the recreational park and near to Bacardi (red)
- C) man-made piece of land disconnected from the main island (blue)

OBJECTIVES

1. Increase the amount of sediments samples from previous research efforts (Huss, Telgus & Olens, 2002) to evaluate the significance of the heavy metals presence in the mangrove ecosystem.
2. Calculate the Retention Factor (RF) value (Yi, 1992; Li & Wong, 2001) in senescent leaves and green leaves from mangroves on the site of study.
3. Calculate the Bioconcentration factor (BCF) (Kleemann, Paulrich & Gahde, 2009) using the soil data and the data from the collection of the green and senescent leaves from the different mangrove species.
4. Assessment of total coliforms and fecal coliforms.

METHODOLOGY

A total of 46 (n=46) sediment samples were taken using 1-2 square stainless steel auger (n=4 for C, 9 for B, and 9 for A). The samplers were removed from the top 15 cm of the soil. Once the sample is taken, the first top 5 inches were discarded. The samples were stored in glass and stored in a refrigerator, stored in order until taken to an EPA licensed laboratory for testing. The method to be used for the analysis of the soil samples in this project is known as the EPA AATCC, this method uses the ICP (inductively coupled plasma-optical emission spectrometry). Except for mercury, for the element is a different method (iron-cadmium atomic absorption) will be used, the methods is specific for soil.

The samples of leaves and soils collected on the Península were evaluated by the same certified EPA private laboratory on the island called SAMCO. A total of 46 new samples were taken scattered across the area were the sediment samples were previously collected (34 samples from each species of mangrove, 7 for green leaves and 7 for senescent leaves). The data were used to determine the concentration of the heavy metals.

BIOCONECENTRATION FACTORS (BCF) AND RETENTION RATION PERCENT (RT%) WHAT THEY MEASURE

Plants can accumulate heavy metals in different part of their organs (shoot, stem, roots, and leaves) or at different level. When bioaccumulation on the leaves occur there is a higher chance of transporting heavy metals to the surrounding environment and possibility to enter in the food chain. BCF = [HMGreen/Leaves] [HMSoil] Kleemann et al. 2009; Hammarström, 2011; Rubio-Foces 2007-2013. Retention Factor (RF %) is a measure from the nutrient use-efficiency concept that measures the amount of nutrients that are reabsorbed by the plant before leaf fall (Iglesia, 1998). Usually, if a soil is deficient in a basic nutrient needed for plant growth, the plant becomes more efficient in the use of the nutrient, recycling it before losing it in the leaves.

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