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In Situ Biofiltration Performance of Hydro-nets as Tested in Moss in San Vicente River in San Jacinto, Pangasinan: An Environmental Assessment and Remediation

Adrian R. Manaois[1] and Jun S. Camara[2]
[1]*Pangasinan State University, Urdaneta City, Pang.*
[2]*San Jacinto National High School, San Jacinto, Pang.*
[1,2]*PARESSU, Inc., San Jacinto, Pang.*

Abstract *- According to Water Environment Partnership in Asia (WEPA), 32 percent of the Philippines' land mass — approximately 96,000 square kilometers — is used for agriculture. In San Vicente, San Jacinto, Pangasinan the water pollution is one of the barangays main problems because of the industrialization that reduces the quality of the water. This study correlates the performance of Ectohydric moss and Moss walls in barangay San Vicente River. Specifically, the water particulates filtered by the Ectohydric Moss and Moss Walls, the significant difference between the level of water biofiltration performance as filtered in the Ectohydric Moss and Moss Walls after 2 hours per day within 3 days, the significant interaction between the Ectohydric Moss and Moss Walls to the level of water biofiltration performance, and the significant interaction between the Ectohydric Moss and Moss Walls water biofiltration performance in terms of environmental thermal gradient. The moss walls were collected in San Jacinto, Pangasinan and the ectohydric moss was collected in Busol Watershed in Aurora Hill, Baguio City. The mosses were authenticated at University of Pangasinan, Dagupan City. The steps involved in this study was the creation of the improvised (12) biofilter hydro-nets. Then 10 grams of moss walls were contained in each out of 6 biofilter hydro-nets and same process to the 10 grams of ectohydric moss were contained in each out of 6 biofilter hydro-nets. The biofilters were exposed in the San Vicente River for 2 hours each day within 3 days and the proportion of the mosses are 2 moss walls biofilter hydro-nets is to 2 ectohydric moss biofilter hydro-nets per day within 3 days. Findings shows that first, the water particulates registered in Ectohydric moss and Moss walls are Lead (Pb), Copper (Cu), Chromium (Cr), Cadmium (Cd), and Nickel (Ni). Second, the total average absorbance rate of heavy metals of ectohydric moss is 0.0492 and the total average absorbance rate of heavy metals of moss walls is 0.0524. Third, no significant difference was observed between the water biofiltration performance of ectohydric moss and moss walls. Lastly, no significant interaction was observed between the two plant species to the absorbed heavy metals. Further, based on the conclusions the research recommends that the mayor and barangay officials of San Vicente, San Jacinto, Pangasinan should plant and culture ectohydric moss and moss walls near to the river, and the future researchers should make a research that will deal to the parameter about environmental thermal gradient of the two plant species.*

Keywords – moss walls, ectohydric moss, biofilter hydro-nets, water biofiltration performance

INTRODUCTION

Water pollution happens when chemicals or dangerous foreign substances are introduced to water, including chemicals, sewage, pesticides and fertilizers from agricultural runoff, or metals like lead or mercury. It is a common global problem that leads to the destruction of natural resources mainly water and danger in the health of people. According to the Environmental Protection Agency EPA (2015), 44 percent of assessed stream miles, 64 percent of lakes and 30 percent of bay and estuarine areas are not clean enough for fishing and swimming. The EPA also states that the most common contaminants in the United States are bacteria, mercury, phosphorus and nitrogen. These come from the most common sources of contaminants, which include

agricultural runoff, air deposition, water diversions and channelization of streams.

Further, Water pollution isn't just a problem for the United States. According to the *United Nations*, 783 million people do not have access to clean water and around 2.5 billion do not have access to adequate sanitation. Adequate sanitation helps to keep sewage and other contaminants from entering the water supply.

Furthermore, water pollution is a major problem in the Philippines. According to *Water Environment Partnership in Asia* (WEPA), 32 percent of the Philippines' land mass — approximately 96,000 square kilometers — is used for agriculture. The primary crops are palay (rice), corn, sugar cane, fruit, root crops, vegetables and trees (for rubber). Increased population, urbanization, agriculture and industrialization have all reduced the quality of water in the Philippines. (borgenmagazine.com) In San Vicente, San Jacinto, Pangasinan the water pollution is one of the barangays main problem because of the industrialization that reduces the quality of the water.

Hence, due to the gradual progress in research, scientist have found that bacteria, plants and other plant-like species can contribute to the natural degradation of contaminants on either water, soil, air or on all of them. Phytoremediation is the process by which plants remove heavy metals and other contaminants from land areas and has 5 methods namely, Phytoextraction (Anderson et al,. 1993), Phytodegration (Prasad, 2011 and Anonymous, 2009), Phytostabilization (Nanthi et al., 2011), Phytovolatization and Rhizofiltration (Atienza and Macaraeg, 2015) though the last method is only used to decontaminate waste water. Besides Phytoremediation, biofiltration is one of the trending processes for decontaminating natural resources and is the focus of the present study, specifically air biofiltration.

Moss species are potential candidates due to the absence of cuticle, high surface to volume ratio, and absence of stomata in their structures (Hipol et. al, 2014).

This study focused on the comparison between the water biofiltration performances of two species namely, ectohydric moss and moss wall.

As a comparison to the study, Hipol et. al. stated their first study in the Philippines which adopted the standard moss monitoring procedure to address Lead (Pb) contamination in the ambient air of Baguio City. Lead is considered as one of the seven criteria pollutants by United States Environmental Protection Agency. The analysis of exposed moss tissues was performed by the researchers using Flame-Atomic Absorption Spectrophotometry by Baguio Water District. Based on the researchers, there is high metal loading observed on the tissues of *Thuidium tamariscellum* (Müll. Hal.) Bosch & Sande Lac. After exposure along and in between major road intersections in the city. There is no significant variation in Pb concentration in the exposed moss as revealed by One-Way Analysis of Variance. This study reports the presence of Pb in the ambient air of Baguio City and the lack of monitoring is harmful to people and environment. Nevertheless, this study offers cost-effective air monitoring method that can be adopted in cities as newer available technology.

Additionally, Harsha et. al. expounded on the biofiltration that is applied to wastewater treatment and other toxic compounds. The main purpose of the biofilter is to remove the dissolved organics, the suspended particles are removed in conventional filter before subjecting the waste water. Based on the researchers the parameters that can affect the performance of a biofilter are the characteristics of filter media, hydraulic and organic loading rate, and filter backwash techniques. The mechanisms, which allow biofilters to work and which must be controlled by the researchers to ensure success, are complex. Ultimately, biotransformation converts the contaminant to biomass, metabolic by-products or carbon dioxide and water. This review paper of the researchers presents an overview of biofiltration technologies for the control of water pollutants, functioning, mechanism and its Designed parameters.

Lastly, Ngo et. al. clarified the biofilter water and waste water treatment and discovered that biofilter is one of the most important separation processes that can be employed to remove organic pollutants from air, water, and wastewater. According to the researchers, even though, it has been used over a century, it is still difficult to explain theoretically all the biological processes occurring in a biofilter. In this paper, the fundamental of biological processes involved in the biofilter is critically reviewed together with the mathematical modeling approach. The important operating and design parameters are discussed by the researchers in detail with the typical values used for different applications. The most important parameter which governs this process based in the findings of the researchers is the biomass attached to the medium. The relative merits of different methods adopted in the measurement of the biomass are discussed by the researchers. The laboratory-and full-scale applications of the biofilter in water and wastewater treatment were also presented by the researchers. Their performances in terms of specific pollutant removal are highlighted.

Thus, Similarities and differences were observed among the three related studies and the present study. While it was true that the present study mainly based on the study of Hipol et. al. (2004) and Ngo et. Al. (2003), there were still some differences that can be observed. The similarities laid on the way the researchers of the study and Hipol et. al, Harsha et. al, and Ngo et. al. used to collect data which was installing the biofilter and the use of ectohydric moss as a biofilter other than the brown algae the present study used.

This study will be significant to the environment to filter the water from water pollutants brought by the increased population, urbanization, agriculture and industrialization. This can also help the community to reduce the water contaminants that could harm the people nearby industrialization and likewise the fishermen, to produce another source of living using for these people due to the abundance of algae in the seashores.

It was only focused on the comparison between water biofiltration performance of the ectohydric moss and moss walls in Brgy. San Vicente River. The duration of the study was only for 3 days. The first collection of the specimens was after 2 hours each day within 3 days duration. The study was conducted this July-September 2017 on the first semester of the School Year 2017-2018.

Moreover, the study was delimited to the use of the biofiltration hydro-nets to determine the water biofiltration performance of the ectohydric moss and moss walls and was only subjected to FLAME-AAS for the data of filtered water particulates. The natural phenomena the biofiltration hydro-nets experienced during its stay on the river for 2 hours within 3 days and its effect to the water biofiltration performance of the two species are beyond the present study.

Finally, this study is limited to the effect of the rainy season to the water biofiltration performance of the Ectohydric Moss and Moss Walls because it may lessen the water particulates that are filtered in the biofiltration hydro-nets.

OBJECTIVES OF THE STUDY

This study correlates the performance of Ectohydric moss and Moss walls in terms of the water particulates that were filtered after 2 hours per day within 3 days, the significant difference between the level of water biofiltration performance as filtered by the mosses after 2 hours per day within 3 days, the significant interaction between the Ectohydric Moss and Moss Walls to the level of water biofiltration performance and the significant interaction between the Ectohydric Moss and Moss Walls water biofiltration performance in terms of environmental thermal gradient.

Hypothesis

1. There is no significant difference between the level of water biofiltration performance as filtered in the Ectohydric Moss and Moss Walls after 2 hours per day within 3 days.

2. There is no significant interaction between the Ectohydric Moss and Moss Walls to the level of water biofiltration performance.
3. There is no significant interaction between the Ectohydric Moss and Moss Walls water biofiltration performance in terms of environmental thermal gradient.

MATERIALS AND METHOD

This study used 12 Container nets out of plane nets, 12 Sponges that was cut into sheets that was good for stabilizing the filtered particulates, 60g of Ectohydric Moss, 24 Sticks with same width and length, 60g of Moss Walls, 12 Ziplocks containers. The sponges, nets and sticks were used in making the hydro-net device while the ziplocks were used to contain the specimens. Further, this study used the Complete Randomized Design (CRD) for it had 6 treatments and 2 replicates per treatments.

Treatments	DAY		
	1	2	3
2 Ectohydric Moss			
2 Moss Walls			

The biofiltration hydro-nets were installed in the river in Brgy. San Vicente, San Jacinto, Pangasinan. There are 2 treatments that will be tested per day within 3 days and each treatment has 2 replicates. The researchers coordinated with the Mayor of San Jacinto, Pangasinan and Barangay officials of Brgy. San Vicente, San Jacinto, Pangasinan, particularly the Barangay Captain. The observation of the river in barangay San Vicente was done afterwards. The development of the design of the biofiltration hydro-nets was finalized after the observation of the river and after finding the location where it will be installed one at a time repeatedly. Twelve biofiltration hydro-nets were built with specific species of moss in it (6 ectohydric moss hydro-nets, 6 moss walls hydro-nets) which will be installed at the Brgy. San Vicente River, San Jacinto, Pangasinan. The collection of the Moss Walls was conducted in Brgy. San Vicente, Oller Street, and Brgy. Guibel where moss walls grow abundantly all throughout the year in San Jacinto, Pangasinan while the Ectohydric Moss was collected in Busol Watershed, Aurora Hill, Baguio City where it was only found. The Ectohydric Moss and Moss Walls collected by the researchers were then authenticated at University of Pangasinan, Dagupan City. Each of the biofiltration hydro-nets were filled with 10 grams of ectohyric moss and moss walls and the researchers were sure that it was the desired species. Further, with the assistance of barangay officials of San Vicente, the Biofilter hydro-nets were installed at the San Vicente River, San Jacinto, Pangasinan. After the 2 hours duration per day within 3 days, the biofilter hydro-nets were collected (6 Ectohydric Moss, 6 Moss Walls) within 3 days. The collected species were oven dried to remove its dryness, then acid digested and after that the specimens were brought and subjected to Flame-AAS at the Chemistry Laboratory, Dela Salle University, Manila, Philippines. Analyses of the data were done by the researchers and the conclusion and recommendation were developed thoroughly.

The researchers used the One-Way Analysis of Variance (ANOVA) to answer the research question number three which states that if there is a significant difference between the level of water biofiltration performance of the ectohydric moss and moss walls in 2 hours per day within 3 days. Further, the Two-Way Analysis of Variance was used to determine the research question number four which states that if there is a significant interaction between the ectohydric moss and moss walls to the level of water biofiltration performance and the research question number five which states that if there is a significant interaction between ectohydric moss and moss walls water biofiltration performance in terms of environmental thermal gradient.

RESULTS AND DISCUSSION

Flame AAS revealed that the sample analyzed had water particulates, as registered, with Lead (Pb), Copper (Cu), Chromium (Cr), Cadmium (Cd), and Nickel (Ni)

Table 1. Average Absorbance Rate of Heavy Metals of the Ectohydric Moss

Heavy Metals	**Absorbance Rate**
Lead (Pb)	0.0006
Copper (Cu)	0.0241
Chromium (Cr)	0.0019
Cadmium (Cd)	0.0031
Nickel (Ni)	0.0195
Total Average Absorbance Rate	0.0492

Table 1 shows the average absorbance rate of heavy metals of ectohydric moss. Of the five (5) heavy metals profiled as registered in the Flame AAS, nickel was absorbed the most and Lead was absorbed the least. Further, it shows the total average absorbance rate of heavy metals of ectohydric moss which is 0.0492

Table 2. Average Absorbance Rate of Heavy Metals of Moss Walls

Heavy Metals	Absorbance Rate
Lead (Pb)	0.0003
Copper (Cu)	0.0284
Chromium (Cr)	0.0016
Cadmium (Cd)	0.0035
Nickel (Ni)	0.0186
Total Average Absorbance Rate	0.0524

Table 2 shows the average absorbance rate of heavy metals of moss walls. Of the five (5) heavy metals profiled as registered in the Flame AAS, nickel was absorbed the most and Lead was absorbed the least. Further, it shows the total average absorbance rate of heavy metals of moss walls which is 0.0524.

Table 3. Two-way ANOVA table on significance of absorbance rates

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	0.000242	2	0.000121	0.711533	0.510478	3.885294
Columns	3.64E-05	1	3.64E-05	0.214284	0.651712	4.747225
Interaction	2.28E-05	2	1.14E-05	0.067076	0.935472	3.885294
Within	0.002039	12	0.00017			
Total	0.00234	17				

Table 3 Two-Way ANOVA shows that it fails to reject the null that there is no significant difference between the water biofiltration performance of ectohydric moss and moss walls with a (*P-value* of 0.510478). This means that there is no significant difference between the water biofiltration performance of ectohydric moss and moss walls.

Further, the table shows that it fails to reject the null that there is no significant interaction between the two plant species to the absorbed heavy metals with a (*P-value* of 0.935472). This means that there is no significant interaction between the two plant species to the absorbed heavy metals.

CONCLUSION AND RECOMMENDATION

Based on the findings, the water particulates registered in Ectohydric moss and Moss walls are Lead (Pb), Copper (Cu), Chromium (Cr), Cadmium (Cd), and Nickel (Ni). Further, the total average absorbance rate of heavy metals of ectohydric moss is 0.0492 and the total average absorbance rate of heavy metals of moss walls is 0.0524. Furthermore, no significant difference was observed between the water biofiltration performance of ectohydric moss and moss walls. Finally, no significant interaction was observed between the two plant species to the absorbed heavy metals.

The researchers recommend that the locals of San Vicente, San Jacinto, Pangasinan qill plant and culture ectohydric moss and moss walls near the river and that the future researchers will develop a research that will deal to the assessment of the parameter about environmental thermal gradient of the two plant species.

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