Impacts of Pyroligneous Acid to Biological and Chemical Properties of Depleted Soil in Bohol, Philippines

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Abstract. This paper presents a part of a bigger research project to validate the use of coconut shell pyroligneous acid (CSPA) in agriculture and to find out its efficacy in rehabilitating a depleted soil in Bohol, Philippines. Specifically, this study will find out the impacts of CSPA on the biological and chemical properties of depleted soil. Pyroligneous acid used in this study is a by-product of coconut shell charcoal making. The CSPA was used in combination with rain water. There were three strengths used, namely: 10%, 20% and 30%. Soil samples from depleted site in an upland farm were brought to the laboratory for analysis. Soil acidity changes in all treatments in an indirect proportion and organic matter has increased by 1 in soils receiving 10% and 30% CSPA and 0.5 in soils receiving 20% CSPA. From a baseline data of an “extremely acid soil”, soils receiving 10% and 20% CSPA lowers to “strongly acid” category while those receiving 30% changed to “very strongly acid”. Soils applied with 10% and 20% CSPA did not change the phosphorous value but it decreased by 3 in those applied with 30% CSPA. All treatments did not make any changes in potassium deficiency. For its biological study, it was found out that soil fauna in all treatments has a moderate Simpson’s index value. There were seven groups of arthropods found, namely: order acarina of class arachnida and orders coleoptera, collembola, dermaptera, diptera, hemiptera, and hymenoptera of class insecta . It was found out that treatments that received high percentage of pyroligneous acid got a high faunal population. The study concluded that pyroligneous acid has demonstrated impacts to the biologicl and chemical aspects of a depleted soil. The higher the rate of CSPA, the higher the population of arthropods. Pyroligneous acid has changed the chemical property in terms of soil pH value, Organic Matter value and phosphorous value. Potassium remains deficient before and after treatment in all levels.

Keywords: pyroligneous acid, depleted soil, arthropods, soil fauna, coconut shell

INTRODUCTION

Soil degradation is now a global problem that requires global efforts to mitigate. This requires new approaches in managing this very important resource for food security and sustainability. It is imperative that for us to mitigate we will find alternative technologies in agriculture to replace those that are considered “destructive” to the life of the soil especially those which are proven to be one of the causes of soil degradation like synthetic fertilizers and pesticides.

According to Stan Cox in his opinion column of Aljazeera, one-third of Earth's soil is degraded because of unsustainable farming methods, which could lead to a major food crisis. He said that “countries whose land is in the worst trouble are often, but not always, countries where large numbers of people live in poverty. In just 10 countries - India, Bangladesh, Brazil, China, Thailand, Mexico, Philippines, Democratic Republic of Congo, Vietnam and Burma - more than 530 million people are feeling the impact of land degradation directly. Worldwide, 1.5bn people are feeling it (Cox, 2012).

In its project preview of Australian Center of International Agricultural Research (ACIAR) Project in Bohol, the World Agroforestry Center noted that "soil erosion and associated losses of nutrients from arable land are an important economic problem in the Philippines and closely associated with ecosystem health and function. These are also issues which are predominantly associated with the steeply sloping uplands and areas with highly erodible soils. Within the agricultural province of Bohol, 45% of the island is designated as agricultural land and supports 80 % of the island's population. However, nearly two thirds of the agricultural land has a slope of greater than 18 % and receives more than two meters of rainfall per year. In a previous ACIAR project LWR/2001/003 it was concluded that activities that have the highest adverse impact on agricultural sustainability (and therefore long term economic sustainability) in the upper Inabanga (the largest watershed on Bohol), included: up and down cultivation on sloping lands, continuous use of nutrient-depleting crops such as corn and cassava, and extensive cultivation of steep upland soils(World Agroforestry Center).

Pyrolysis can serve as wood waste recycling process which will reduce environmental hazards. Its by-product, the pyroligneous acid is a potential input to replace chemical pesticides for organic agriculture purposes. In a slide presentation of Laemsak N. as cited by Tiilikkala et.al. , it is noted that one of the fast growing areas of bio-business is based on the use of pyrolysis technologies. Charcoal (biofuel and biochar) has been the main product of the conventional pyrolysis for a long time in most of the cases but recently byproducts of the process (green chemicals) have become more and more important. Locally produced wood vinegar has been used as a pesticide in countries where synthetic chemicals have not been available, or where the price of the chemicals has been too high for small scale farmers. Globally, the need to minimize the environmental risks resulting from pesticides leaching to ground water and waterways has bolstered the use of wood vinegar as a biocide and pesticide (Tiilikkala et al 2010). Hence, there is a need also to look into the impacts of this input to the biological and chemical aspects of the soil to help determine its usefulness in pest and fertilizer management and therefore can be of benefit in restoring depleted soils.

The aim of this research was to find out the impacts of coconut shell pyroligneous acid on the biological and chemical properties of a depleted soil in Bohol, Philippines.

METHODOLOGY

Research Location

This research project was conducted in a controlled condition at Oikos Garden, Bilar, Bohol, Philippines. However, soil samples were taken from a degraded upland community of Carmen, Bohol.

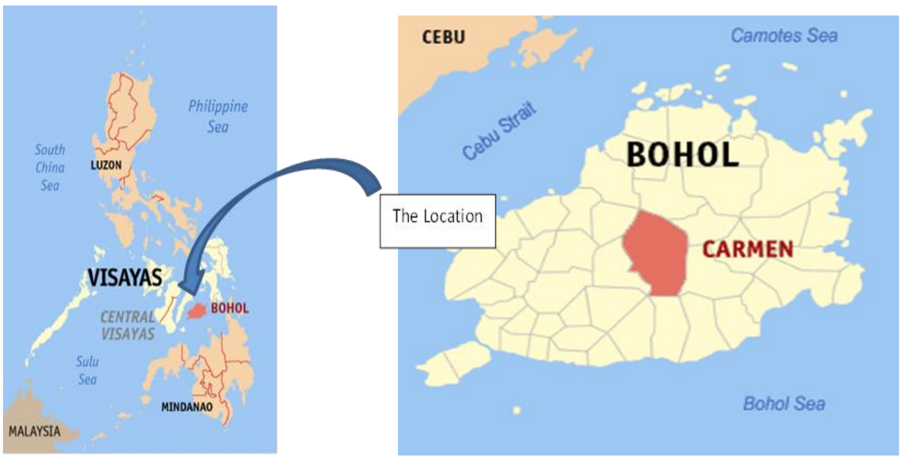

Fig. 1 Map of Research Site

There were two experimental set-ups established: one for the study of soil fauna and one for the study of chemical properties.

A. Soil fauna study

This aspect of the study was to find out the effect of coconut shell pyrolignoeus acid on the soil inhabitants of degraded soil. Soil samples were taken from the degraded uplands of Carmen, Bohol. Soil was analyzed as clay loam with a pH value of 4.1 which is “extremely acidic” and 3.0% organic matter. It has a phosphorous content of 12ppm and deficient in potassium.

Polyethylene terephthalate (PET) bottles (1.5 liter soda bottle) were used as observation containers. PET bottles were cut crosswise leaving the straight portion and holes were made on the sides of the bottles. These bottles were filled up with the collected soil and treatments were assigned. The treatments were as follows: Control, 10% CSPA, 20% CSPA and 30% CSPA by volume. There were four bottles assigned for each treatment as observation of soil fauna was done four times in a weekly basis. Hence, 16 PET bottles with soil were embedded on the ground at 20 cm deep and secured in a secluded area of the experimental field. Four observations for each treatment were done 7, 14, 28 and 42 days after the PET bottles with soil were embedded on the ground.

To collect the organisms present in the soil, an improvised Berlese funnel was prepared using a one gallon empty plastic water container. Soil was placed on the funnel with a 100w bulb on top of the soil. Underneath the funnel was a glass with alcohol to catch the soil organisms. Soil arthropods extracted from the soil were identified under the microscope.

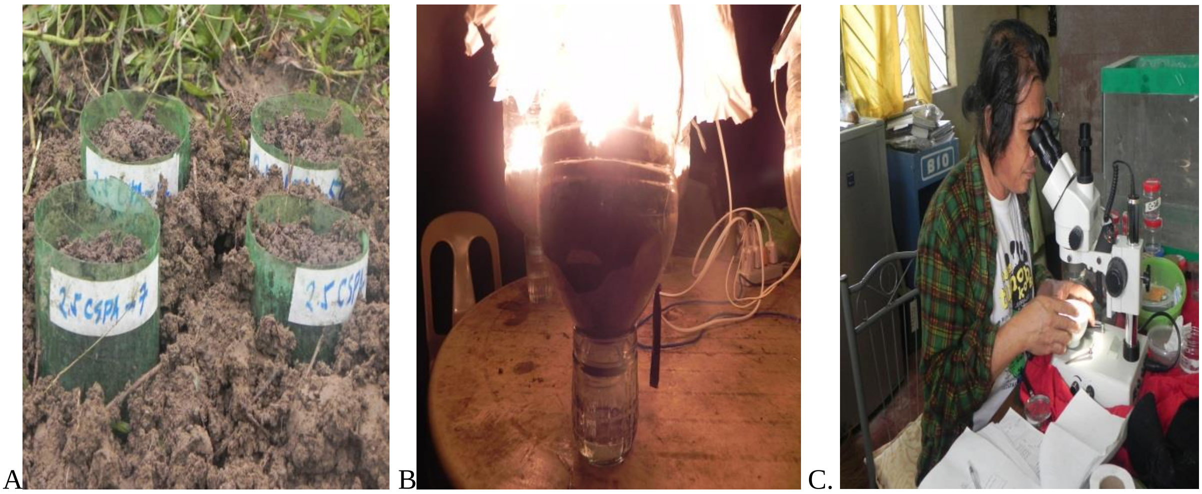

Fig 2. A.Soil Samples in PET Bottles B. Improvised Berlese Funnel C. Identification of Arthropods

B. Study on chemical property

Experimental set-up was established in a nursery of the Oikos Garden. This part of the study was to find out the impact of CSPA on soil property. Black plastic potting bags were used. Using the soil samples collected from the degraded upland of Bohol, a randomized complete block design (RCBD) was installed. Four bags were planted with pechay for each treatment and replicated four times. The treatments were as follows: Control (No CSPA), 10% CSPA, 20% CSPA and 30% CSPA. First application of CSPA was done one week before planting and the second was done one week after planting. Subsequent application was done on a weekly basis. Soil analysis was done before and after the study

A. 

B. 

Fig. 3. A. Experimental Set-up B. Pechay 30 days after planting

RESULTS AND DISCUSSION

A. Soil Fauna

Data collection showed one order of Arachnida (Acarina) and six orders of Arthropods that were identified in all treatments. The arthropods identified included the following: Coleoptera, Collembola, Dermaptera, Diptera, Hemiptera and Hymenoptera. Each treatment has a population of 8, 8, 33 and 55 for Treatments 1, 2, 3 and 4, respectively. Figure 4 shows the total population of arthropods in all treatments after four collection and counting periods that is 7, 14, 28 and 42 days after the PET bottles were embedded on the ground.

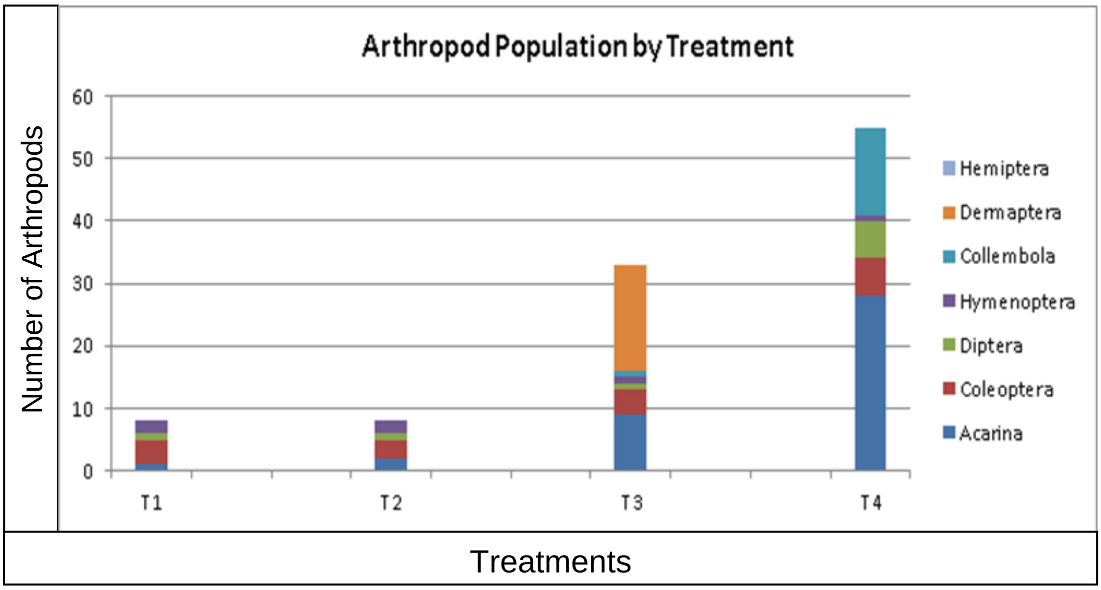

Fig. 4 Total Arthropod Population by Treatment

Fig. 5. Representative arthropods collected from soils in PET bottles

Simpson's dominance index indicated that all treatments had a moderate value. However, based on population data, Treatments 3 and 4 showed higher population than Treatments 1 and 2. It means high percentage of CSPA will increase population of soil organisms.

Table 1. Arthropod Population by Order Per Treatment

Treatments	Arthropods	Population by Order	Total Population Per Treatment
Treatment 1 (Control)			8
	Acarina	1	
	Coleoptera	4	
	Diptera	1	
	Hymenoptera	2	
Treatment 2 (10%)			8
	Acarina	2	
	Coleoptera	3	
	Hemiptera	1	
	Hymenoptera	2	
Treatment 3 (20%)			33
	Acarina	9	
	Coleoptera	4	
	Collembola	1	
Treatment 4 (30% CSPA)	Dermaptera	1	
	Diptera	1	
	Hymenoptera	17	
Treatment 4 (30% CSPA)			55
	Acarina	28	
	Coleoptera	6	
	Collembola	6	
	Dermaptera	1	
	Hymenoptera	14	

B. Chemical property

Baseline information about the soil used in this study was obtained and it was found out that such soil is characterized as clay loam with a pH value of 4.1 which is extremely acid.. It has an organic matter content of 3% with 12 ppm Phosphorous and deficient in Potassium.

After one season of pechay (one month), soil analysis indicated some changes as reflected in Table 2.

Table 2. Soil Analysis Before and After Treatment

Baseline Soil Analysis		Treatment 1(Control)	Treatment 2	Treatment 3	Treatment 4
Soil pH	4.1	4.1	5.2	5.1	4.5
Organic Matter (%)	3.0	3.0	4.0	3.5	4.0
Phosphorous (ppm)	12	12	12	12	9
Potassium (ppm)	Deficient	Deficient	Deficient	Deficient	Deficient

Soil acidity or pH value changes in all treatments in an indirect proportion. This implies that CSPA can lower the pH value of soil and so it can neutralize soil acidity. From a baseline data of an "extremely acid soil", Treatments 2 and 3 lowers to "strongly acid"category while Treatment 4 changed to"very strongly acid". Treatments 2 and 3 did not change the phosphorous value but it decreased by 3 in Treatment 4. All treatments did not make any changes in potassium deficiency. The organic matter has increased by 1 in Treatments 2 and 4 and 0.5 in Treatment 3. This study confirms the work of Ll Zhong-hui and Wang Xu-dong that addition of wood vinegar to the soil decreases soil pH.

CONCLUSION

Based on the result of the study, it is concluded that coconut shell pyroligneous acid has demonstrated impacts to the biological and chemical aspects of depleted soil. The higher the rate of CSPA, the higher the population of arthropods. CSPA has changed the chemical property in terms of soil pH value, Organic Matter value and Phosphorous value. Potassium value remains deficient before and after treatment at all levels.

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