International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 21, No. 2, p. 1-7, 2022

INNSPUB

RESEARCH PAPER

OPEN ACCESS

Ameliorative potential of rice hull and straw in the ecological restoration of mine degraded soils

Gelian Aranas-Rasonable*[1], Grethyl Catipay-Jamero[1], Chris P. Rasonable[2], Gemma A. Asufre[3]

[1]*Cabadbaran City National High School, Brgy. 12, Cabadbaran City, Agusan del Norte, Philippines*

[2]*Calamba National High School, Brgy. Calamba, Cabadbaran City, Agusan del Norte, Philippines*

[3]*Department of Agriculture, Region XIII, Butuan City, Agusan del Norte, Philippines*

Article published on August 10, 2022

Key words: Rice straw, Rice hull, Amelioration, Mine degraded soil, Wastes, Mining

Abstract

Rice hull and straw are renewable wastes contain 28-30% of inorganic and 70-72% of organic compounds. Its ameliorative potential in enhancing the physicochemical properties of mine degraded soils was investigated. Soils collected from Backfill Material/Overburden (BM) and desilted materials (DM) from settling ponds of Carrascal Nickel Corporation (CNC) were used following six treatments. BM and DM from settling ponds were treated with rice hull and rice straw with 2:1 ratio by weight, respectively. After ameliorating soils from overburden and silted materials from CNC with rice straw and rice hull, observations showed that there are no significant differences in pH, % Organic Matter (OM) and phosphorous (P) between treatments; there is high significant difference ($p<0.01$) in potassium (K) between treatments except between treatment 3 (soil 1 with rice straw) and treatment 6 (soil 2 with rice hull) where there is no significant difference noted; and the concentrations of Ca, Mg, S and Zn in soils with rice hull did not differ with soils before amelioration, but differed to soils with rice straw, while results in soil texture exhibited otherwise. Therefore, rice straw and rice hull have ameliorative properties that will improve the physico-chemical characteristics of mine degraded soils. It is recommended that rice straw and rice hull will be allowed to decompose in mine degraded soils to enhance its physico-chemical properties. It is also recommended to conduct studies on the response of different crops to mine degrade soils ameliorated with rice straw and rice hull.

* **Corresponding Author:** Gelian Aranas-Rasonable ✉ gparanas@gmail.com

Introduction

Nickel mining operations are large industries in the Philippines that extensively impacted large land areas. The surface mining of nickel seriously damages the surface soil, removing the local flora and fauna with the removal of the soil surface horizons. Also, degradation problems are sometimes caused by mining waste such as overburden, discards and mine effluents. Revegetating the area is one way to stabilize the surface soil. However, mine degraded soil is a difficult medium to prepare for a successful re-vegetation. It is possible to revegetate the covering topsoil, but the sustainability of conventional procedures is often poor. Liming and fertilizing the covering topsoil, does not necessarily ensure a viable growth medium for plants for prolonged periods. Vegetation would hardly survive due to unsustainable growth of the roots. As a result, the covering topsoil becomes unstable, and susceptible to erosion. Fertilization and liming to augment soil nutrient and regulate soil pH are recommended but very expensive. Large amounts of lime and fertilizer are also used to rehabilitate these areas, but are often not sustainable as the soil is bare and susceptible to erosion during rainfall and high temperature during dry months which considerably changes soil pH. However, discontinuation of fertilization can cause decrease production and vegetative cover on marginal sites. Presently, no effective and economical mitigation is being recommended to revegetate the area and create a sustainable system. The challenge is thus to find alternative methods to which will be sustainable.

Understanding that surface mining often require removal of surface soil horizons instantly shrinks the soil organic matter pool. This resulted to the ability of soil to replenish organic matter via net primary production that is repressed by altered nutrient, water and soil temperature regimes. Then, water-holding capacity is reduced by lack of soil organic matter and by increased runoff capacity due to lower porosity (increased bulk density) and infiltration. Soil microbial activity is also negatively affected. Amelioration using organic amendments affect soil properties in numerous and variable ways (Larney *et al.*, 2009). Soil organic matter is generally considered the single most important property affecting quality and functioning of soils (Gregorich *et al.*, 1994). As expected, application of organic amendments results in an immediate increase in soil organic carbon, which is generally proportional to the amount of carbon applied (Chantigny *et al.*, 1999). However, in cases of high background levels and or high variability, changes in soil organic carbon following low or moderate application rates may not be measurable or detectable (Viaud *et al.*, 2011). The rate of decomposition of organic amendments and soil organic carbon remaining over the long term vary with intrinsic quality of the amendment (Lashermes *et al.*, 2009). Carbon in organic amendments was originally fixed by plants through photosynthesis. The chemical composition and physical characteristics of organic amendments will depend on the type of vegetation from which they are derived (e.g., trees vs. annual agricultural crops) and on the fate and transformation of the plant carbon following its harvest. For instance, cereal straw can either be incorporated directly into the soil or become part of manure (via bedding), which is eventually land applied in fresh or composted forms. If the latter, it will undergo decomposition (mineralization and transformation) that will modify its properties, more so during composting, where labile carbon forms are mineralized such that the remaining carbon is more stable and results in greater increases in soil organic matter per unit of carbon applied than fresh plant materials in the long term (Lashermes *et al.*, 2009). Effects of the organic matter to the soil can be direct, through the intrinsic properties of the organic amendments themselves, or indirect, by modifying soil physical, biological and chemical properties. Hence, the type of organic amendments used as ameliorant matters. High organic carbon content provides an instant energy source, which boosts soil microbial activity, and organic matter improves poor soil physical conditions resulting from topsoil loss and compaction.

While rice husk and straw are largely considered waste products are often burned in preparation for the next planting season or dumped on landfills (Gummert, 2003).

Rice hull and rice straw are produced in volume during rice harvest in the Philippines. Burning of rice straws and other agricultural wastes contributes more to air pollution than vehicle emissions (Philstar Global, 2006). Hence, disposal of rice straw as a by-product resulting from the cultivation of rice is causing worldwide environmental and health problems. According to rice farmers in Caraga region, rice hull and straw are burned as being the cheapest method of disposal. The practice which is observed to be common in rice fields in the region does not only generate smoke, but also breathable particulate matter and dust that contains crystalline silica and other health hazard substances (Damatty and Hussain, 2009). Approximately 5,073,880 tons of rice hull and straw are burned annually according to the Industrial Technology Development Institute (ITDI) of DOST, in every 250 kg of rice straw and 100 kg of rice hull burned per ton of rice produced.

Utilization of rice straw and rice husks has been practiced in the field for some time (Ponamperuma, 1982). Research has shown that assimilation of rice straw and rice hull with the soil can significantly improve soil properties through decreasing soil bulk density, improving soil pH, accumulating organic carbon, enhancing available nutrients and eliminating heavy metals from the system, which ultimately enhancing crop yields (Saunders and Williams, 1955). Rice hull and straw as annually renewable wastes contain 28-30% of inorganic and 70-72% of organic compounds (Sergienko *et al.*, 2004). According to Koz'mina, (1976) the composition of the organic compounds includes C, H, O, N. The inorganic components are represented mainly by silica (Sergienko *et al.*, 2004).

These organic materials are not yet tested as ameliorant to mining degraded soil. Thus this study investigated the ameliorative potential of rice hull and straw in the ecological restoration of mine degraded soils. Specifically, the study determined the physico-chemical parameters of mining degraded soils before and after the application of rice straw and rice hull; and the significant difference in the physico-chemical parameters of mining degraded soils before and after the application of rice straw and rice hull. The results of the study can be used as bases in recommending rice straw and rice hull in improving and restoring mine degraded soils. Utilization of rice straw and rice hull will also decrease volume of farm wastes and will improve soil properties by decreasing soil bulk density, enhancing soil pH, adding organic carbon, increasing available nutrients and removing heavy metals from the system, ultimately increasing crop yields. The study was conducted in three months' period including the collection and analysis of sample. Experimental phase of the study was done in pot trials in controlled condition for thirty days. Analyses of soil samples was done in Integrated Laboratory of the Department of Agriculture Caraga Region.

Materials and methods

Collection of Soil Samples and Ameliorants (rice hull and rice straw)

Soil samples were collected from the mine out areas of Carrascal Nickel Corporation (CNC) at Carrascal, Surigao del Sur. This mining industry practiced surface soil extraction for nickel ore. Soil samples were brought to Soriano, Cabadbaran City for the experimental study.

Decomposing phase of rice hull and rice straw were collected from RTR Rice Mill and RTR rice fields, respectively and were also brought to the experimental site at Soriano, Cabadbaran City.

Preparation and Amelioration of Soil Media for Pot Trials

Soils collected from Backfill Material/Overburden and desilted materials from settling ponds of CNC were prepared according to the following treatments:

Treatment 1- (Soil 1- soil from Backfill Material/Overburden from mining areas with no ameliorants applied)

Treatment 2- (Soil 2- soil from Desilted Material from settling ponds with no ameliorants applied)

Treatment 3- Soil 1 + Rice Straw in 2:1 ratio by weight

Treatment 4- Soil 2 + Rice Straw in 2:1 ratio by weight

Treatment 5- Soil 1+ Rice Hull in 2:1 ratio by weight

Treatment 6- Soil 2 + Rice Hull in 2:1 ratio by weight

Assigned ameliorants were thoroughly mixed into the soils collected from CNC in 2:1 ratio by weight using shovel. There were 12 plastic pots as replicates of each treatment. The ameliorated soils in the pots were allowed to stand for 30 days to allow cohesion of the mixture.

Analyses of Samples

Two batches of soil samples were submitted for the physicochemical analyses such as pH, N, P, K, Ca, Mg concentrations, porosity, bulk density, and organic matter content at the Department of Agriculture Caraga Region Soils Laboratory, Taguibo, Butuan City. The first batch were the soil samples collected from CNC Backfill Material/Overburden and desilted material from settling ponds) before amelioration were submitted for initial analysis of the physicochemical parameters. While the second batch of samples that composed the ameliorated soils from treatments 3-6 were submitted also for physicochemical analysis after allowing the mixture to stand for 30 days to allow cohesion of the mixture.

Statistical Analyses

Analysis of Variance (ANOVA) was performed using SPS software in the determination of significant difference of the physico-chemical parameters between treatments.

Results and discussion

Rice straw and rice hull were tested as ameliorants to soil from overburden and desilted materials from CNC. Comparison of physico-chemical parameters were determined before and after the amelioration processes. Table 1 showed that there is an increase on the mean results of%OM, P, and K in both soil ameliorated with rice hull and straw. Results in Table 2 shows that there are no significant differences (p> 0.05) in pH,% Organic Matter (OM) and phosphorous (P) between treatments.

Table 1. Mean results of the physicochemical parameters of soils from CNC before and after application of ameliorants.

		Physicochemical Parameters			
	Soil Samples	pH	Organic Matter (%)	P (ppm)	K (ppm)
Before Amelioration	S_1- (Soil 1 BM) soil from backfill material/overburden	6.79^a	2.3^a	23^a	97^e
	S_2- (Soil 2 DM) soil from desilted material from settling ponds	6.93^a	2.1^a	22^a	90^f
After Amelioration	T_3- Soil 1 BM + Rice Straw	6.72^a	4.3^a	53^a	149^{bc}
	T_4- Soil 2 DM + Rice Straw	6.65^a	4.3^a	50^a	196^a
	T_5- Soil 1 BM + Rice Hull	6.21^a	3.7^a	41^a	132^d
	T_6- Soil 2 DM + Rice Hull	7.08^a	2.5^a	47^a	156^{bc}

Table 2. Physicochemical parameters of soils from CNC with and without ameliorants.

	Physicochemical Parameters								
Soil Samples	pH	Organic Matter (%)	P (ppm)	K (ppm)	Ca	Mg	Zn	S	Texture
S_1- (Soil 1 BM) soil from backfill material/overburden	6.79^a	2.3^a	23^a	97^e	D	D	D	D	Medium
S_2- (Soil 2 DM) soil from desilted material from settling ponds	6.93^a	2.1^a	22^a	90^f	D	D	D	D	Medium
T_3- Soil 1 BM + Rice Straw	6.72^a	4.3^a	53^a	149^{bc}	S	S	MD	MD	Medium
T_4- Soil 2 DM + Rice Straw	6.65^a	4.3^a	50^a	196^a	S	S	MD	MD	Medium
T_5- Soil 1 BM + Rice Hull	6.21^a	3.7^a	41^a	132^d	D	D	D	D	Heavy
T_6- Soil 2 DM + Rice Hull	7.08^a	2.5^a	47^a	156^{bc}	D	D	D	D	Heavy

Note: Numbers in a column with different letters denote significant difference

Legend: VD- Very Deficient; D- Deficient; MD-Moderately Deficient; MS- Moderately Sufficient; S- Sufficient

Grinding the soil to finer texture

Mixing mine soil with the rice hull and straw

Placing mixed mine soil and rice hull and straw in pots for replicates

Fig. 1. Mixing of the soil with the ameliorants and placing replicates in the pots.

Results also revealed a high significant difference ($p<0.01$) in potassium (K) between treatments except between treatment 3 (soil 1 with rice straw) and treatment 6 (soil 2 with rice hull) where there is no significant difference (p value, 0.0535) noted.

This means that rice straw and rice hull did not affect the pH, %OM and P but affected the concentration of K in soils from overburden and desilted materials from CNC after the ameliorative period (30 days). These physico-chemical properties of the soil had already high pH; had moderately deficient to sufficient % OM; and deficient to sufficient P. Concentrations of K increased after ameliorating rice straw and rice hull to the soils from overburden and desilted materials from CNC.

For the results of the concentrations of Ca, Mg, S and Zn, soils with rice hull did not differ with soils before amelioration but differed to soils with rice straw, while results in soil texture exhibited otherwise. Rice straw enhanced the Ca and Mg from deficient to sufficient while S and Zn from deficient to moderately deficient. Soils did not change its medium texture when ameliorated with rice straw but changed to heavy after ameliorated with rice hull.

The improvement of soils from overburden and silted materials from CNC is due to the inorganic and organic compounds that rice straw and rice hull contain with 28-30% and 70-72%, respectively (Sergienko *et al.*, 2004). According to Koz'mina, (1976) the composition of the organic compounds includes C, H, O, N while inorganic components are represented mainly by silica (Sergienko *et al.*, 2004). These materials significantly improve soil properties by decreasing soil bulk density, enhancing soil pH, adding organic carbon, increasing available nutrients and removing heavy metals from the system, ultimately increasing crop yields (Saunders and Williams, 1955).

Conclusion and recommendations

After ameliorating soils from overburden and silted materials from CNC with rice straw and rice hull, observations showed that there are no significant differences in pH,% Organic Matter (OM) and phosphorous (P) between treatments; there is high significant difference ($p<0.01$) in potassium (K) between treatments except between treatment 3 (soil 1 with rice straw) and treatment 6 (soil 2 with rice hull) where there is no significant difference noted; and the concentrations of Ca, Mg, S and Zn in soils with rice hull did not differ with soils before amelioration, but differed to soils with rice straw, while results in soil texture exhibited otherwise. Therefore, rice straw and rice hull have ameliorative properties although not statistically significant that will improve the physico-chemical characteristics of mine degraded soils. It is recommended that rice straw and rice hull will be allowed to decompose in mine degraded soils in a longer period than 30 days to allow cohesion of the ameliorants with the soil and enhance its physico-chemical properties. It is also recommended to conduct studies on the response of different crops such as Pinto peanut or "mani-mani" (*Arachis pintoi*) as its bioremediative plant to mine degraded soils ameliorated with rice straw and rice hull to be used as basis on what vegetation use as one of the final restoration measures in surface mining areas.

Acknowledgements

Science investigatory project is not an individual work, but requires teamwork to make it happen; hence the researchers would like to show their heartfelt appreciation and deep gratitude to all the persons who contributed for the success of this research endeavor. First of all, to our adviser Ma'am Gemma A. Asufre for guiding us in the conduct of this research and providing technical assistance in doing our study and in analysis of our results. To Raian Jamero and the Carrascal Nickel Corporation management for allowing us to acquire soil samples from their mine site. To Sir Jonivil L. Vidal for giving us the opportunity to join the contest and gain valuable experience in the field of research. To our parents, teachers and friends who in one way or another extend their moral, financial and spiritual support and most especially to our Almighty God Jehovah, the source of good wisdom and all desirable things.

References

Chantigny MH, Angers DA, Beauchamp CJ. 1999. Aggregation and organic matter decomposition in soils amended with de-inking paper sludge. Soil Sci. Soc. Am. J **63,** 1214-1221.

Damatty AAE, Hussain I. 2009. Appropriate Technologies for Environmental Protection in the Developing World." Department of Civil and Environmental Engineering, The University of Western Ontario, London, Ontario, Canada © Springer Science + Business Media B.V.

Gregorich EG, Carter MR, Angers DA, Monreal CM, Ellert BH. 1994. "Towards a minimum data set to assess soil organic matter quality in agricultural soils." Can. J. Soil Sci **74,** 367-385.

Gummert M. 2013. "A second life for rice husk." The Responsible Business Summit New York. (May): https://www.eco-business.com/news/second-life-rice-husk/.

Koz'mina EP. 1976. (Ed.). "Ris i ego kachestvo [Rice and Its Quality]." Moscow: Kolos 1976.

Larney FJ, Olson AF, Miller JJ, DeMaere PR, Zvomuya F, McAllister TA. 2009. Physical and chemical changes during composting of wood chip-bedded and straw-bedded beef cattle feedlot manure. Journal of Environmental Quality **37,** 725-735. https://doi.org/10.2134/jeq2007.0351

Lashermes G, Nicolardot B, Parnaudeau V, Thurie` s L, Chaussod R, Guillotin ML, Line`res M, Mary B, Metzger L, Morvan T, Tricaud A, Villette C, Houot S. 2009. "Indicator of potential residual carbon in soils after exogenous organic matter application." Eur. J. Soil Sci **60,** 297-310.

Philstar Global. "Burning of rice straw, agri waste threatens the environment" Philstar Global, July. 2006. https://www.philstar.com /business/agriculture/2006/07/30/350114/burning-rice-straw-agri-waste-threatens-environment#as7V A4Ik85vwDkB7.99

Ponamperuma FN. 1982. Straw as source nutrient for wetland rice. *In:* Banta, S., Mendoza, C.V., (eds), "Organic matter and rice." Los Baños, The Philippines: IRRI, 117-136.

Sergienko VI, Zemnukhova LA, Egorov AG, Shkorina ED, Vasilyuk NS. 2004. Vozobnovlyaemye, 2004 istochniki khimicheskogo syr'ya: kompleksnaya pererabotka otkhodov proizvodstva risa i grechikhi [Renewable Sources of Chemical Raw Materials: Complex Processing of Rice and Buckwheat Production Waste]. Russian Chemical Society Journal of them. DI. Mendeleev **XLVIII(3),** 116-124.

Viaud V, Angers DA, Parnaudeau V, Morvan T, MenasseriAubry S. 2011. 'Response of organic matter to reduced tillage and animal manure in a temperate loamy soil." Soil Uses Manage **27,** 84-93.

Williams BL, Shand CA, Hill M, O'Hara C, Smith S, Young ME. 2008. "A procedure for the simultaneous oxidation of total soluble nitrogen and phosphorus in extracts of fresh and fumigated soils and litters". Communications in Soil Science and Plant Analysis, 10.1080/00103629509369283, 26, **1-2,** 91-106.