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An Inventory of Pteridophytes in and around gold-mined areas in Tumpagon, Cagayan De Oro City, Philippines

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Abstract: Gold mining brings several benefits to developing countries like the Philippines. Although the industry produces economic gains and provides employment, it destroys the environment through deforestation, vegetation removal and loss of biodiversity. In this study, assessment on the distribution, abundance and status of Pteridophytes in and around the gold-mined areas in a village in Cagayan de Oro City, Philippines were considered. Collection and identification of Pteridophytes were done in the established sampling points outside and inside the mining area. Results of the study revealed that the diversity of Pteridophytes outside the mining area is higher than inside the mining area. *Cyathea contaminans,* an endangered species was observed outside and inside the mined site. Decrease in Pteridophytes diversity within the mining area can be attributed to habitat loss and fragmentation.

Key words: Pteridophytes, Surface mining; Ferns; Fern allies

1. Introduction

The Philippines is one of the countries in the world considered as both a hotspot and a mega diverse country placing it as one of the top priority hotspots for global conservation (International, 2013). The country's floral diversity is exceedingly rich with 10,000 to 14,000 species of plants of which more than half are endemic. Altogether, the country is host to some 5 % of the world's species of flora and is ranked 5th worldwide in terms of plant diversity (Republic of the Philippines, 2009; State of Philippine Biodiversity (BMD-PAWB), 2016). According to Barcelona (Barcelona, 2002), around 1,100 species of Pteridophytes have been recorded and 26% of this is endemic to the country.

The Pteridophytes are long known for their medicinal and therapeutic utility. In ancient period, these plants were prescribed as herbal extract for the cure of several diseases (Singh et al., 2010). Besides having various medicinal properties, they are also greatly valued as ornamentals and used for a variety of commercial and environmental purposes. Majority of these plants are moisture and shade-loving and dependent upon the microclimatic conditions of the region for their successful survival. Thus, factors like climate change, increasing urbanization, industrialization, encroachment of forest lands, unplanned developmental activities, over exploitation of natural resources, pose a major threat to the survival of these groups of plants (Dixit, 2000).

As significant as being one of the mega diverse countries, the Philippines is also considered as the 5th most mineral-rich country in the world, with the third largest reserves of gold, the fourth largest copper and the fifth largest nickel reserve (Philippines: Mining Laws and Regulations Handbook, 2013; Marasigan, 2015). Mining and mineral processing have the potential to be important sources of income and a driving force behind broader economic development (Eggert, 2001). However, both small and large-scale mining operations are inherently disruptive to the environment (Makweba and Ndonde, 1996). With this, the country is faced with a great challenge in utilizing the rich available mineral resources for economic growth and development without compromising its ecological integrity and species diversity. In this study, the species richness, abundance and diversity of Pteridophytes as well as their endemism, economic importance and conservation status in and around the small scale gold mining area of Brgy. Tumpagon, Cagayan de Oro, Philippines were assessed to determine the impacts of surface mining to Pteridophyte diversity. Information generated can be used as basis for

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possible Pteridophyte conservation strategies while pursuing economic development.

2. Materials and methods

Tumpagon, as shown in Fig. 1, is among the hinterland barangays of Cagayan de Oro City located at 8°19'19"N and 124°28'49"E and has a total area of 11,926.596 hectares. It is bounded by Iponan river on the north and west side; the Province of Lanao del Norte on the south, and barangay Pigsag-an on the east. Tumpagon has abundant supply of sand and gravel as well as gold. The gold mining activity in Tumpagon, Cagayan de Oro started during the 1950's up to the present. The method is surface mining through hydraulic technique which utilizes highly pressurized water to dislodge the surface soils and extract the gold nuggets from the area.

As per record, the City Local Environment and Natural Resources Office through the City Mining Regulatory Board confirmed no existing mining concessions for gold, copper, or any other minerals. As such, any mining activities in the area are all considered illegal (Interview; Engr. Rodante B. Felima).

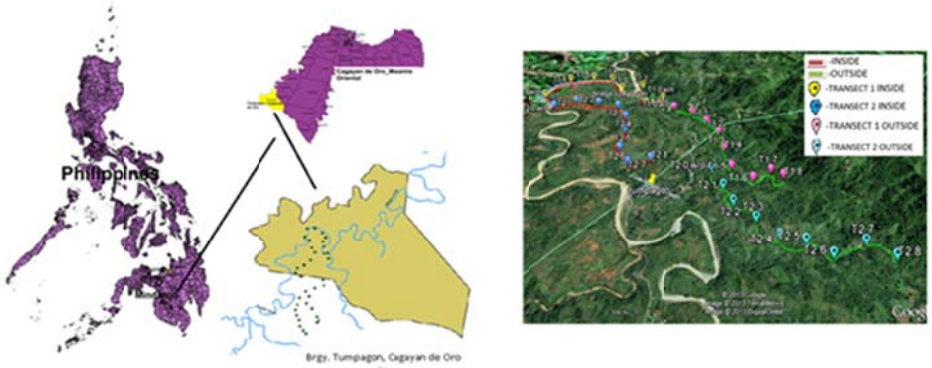

Fig. 1: Map showing all the established transect s and sampling stations within and outside the mining area of Brgy. Tumpagon, Cagayan de Oro City

Four 2-km transect lines were established in the area (two 2-km transects within mine areas and another two 2-km transects outside mine areas with at least 5 km distance). Each line was divided into 9 sampling points placed every 250 m. ensuring that the two 2-km sampling stations were parallel with each other and had a distance of at least 2 km. For each sampling point, five 1x1 meter quadrats were established to sample the Pteridophytes.

The collected pteridophytes were identified onsite by an expert and verified using taxonomic keys from floras, books and monographs (Zamora and Co, 1986; Pelser et al., 2011; Amoroso et al., 1995). The conservation status of floral species was assessed based from The National List of Threatened Philippine Plants (DENR AO.2015) and the IUCN Red List. Photographs were taken and herbarium specimens were made for further verification by the experts.

Diversity indices including dominance, evenness, Simpson Index and Shannon's Index were performed using PAST software version 2.14 (Hammer et al., 2001).

3. Results and discussion

A total of 36 species under 17 families of pteridophytes were identified in the study area (Figs. 2a-d).

Fig. 2a: Showing the habit of: A- *A.nidus* L; B- *D.esculentum;*C- *B. orientale* L.; D- *C.contaminans*; E- *S. glauca* ; F-*D. solida*; G- *D. linearis*; H- *G. vulcanica*; I- *O. chinensis*

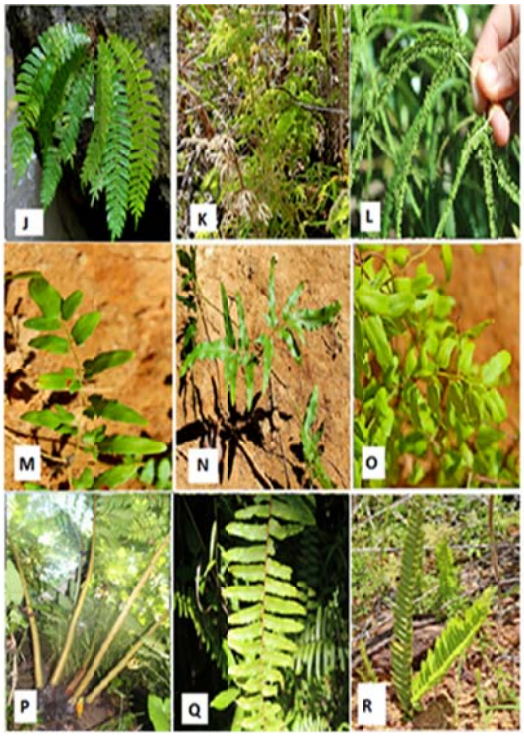

Fig. 2b: Showing the habit of : **J-** *C. crenata*; **K-** *L. cernua*; **L-** *L. circinnatum*; **M-** *L. flexousum*; **N-** *L. japonicum*; **O-** *L. microphyllum*; **P-** *A. palmiformis*; **Q-** *N.biseserata*; **R-** *N. cordifollia*

Fig. 2c: Showing the habit of: **S-** *C.sagitta*; **T-** *D. quercifolia*; **U-** *Microsorum punctatum M. punctatum*; **V-** *P. piloselloides*; **W-** *P. nummularifolia*; **X-** *A.reticulatum*; **Y-** *P. calomelanos*; **Z-** *S.delicatula*; **AA-** *S. cupressina*

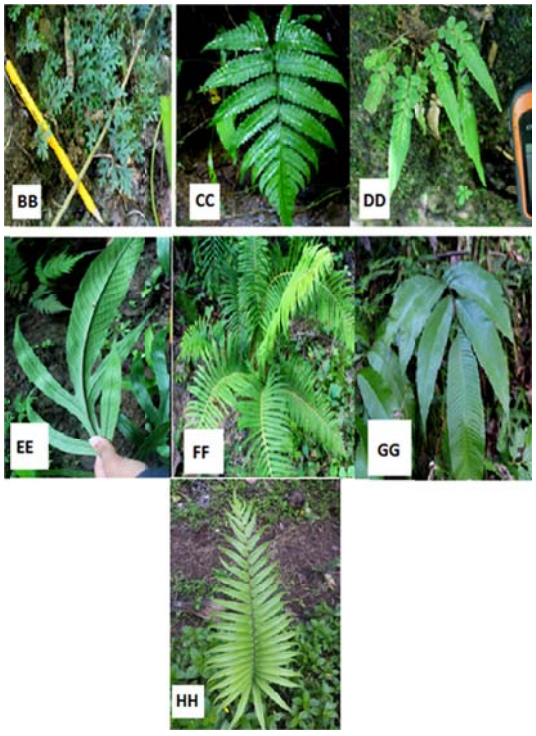

Fig. 2d: Showing the habit of: **BB-** *S. ornata*; **CC-** *P. macrodonta*; **DD-** *T. aurita*; **EE-** *T. decurrens*; **FF-** *C. parasitica*; **GG-** *P. asperum* ; **HH-** *S. unitus*

The Pteridophytes as shown in Fig. 3 were composed of 11% Fern allies and 89% True fern species. The fern allies are made up of *L. cernua* under family Lycopodiaceae and 3 were Selaginellaceae species: *S. delicatula, S.cupressina* and *S. omata.* The rest of the families are true ferns.

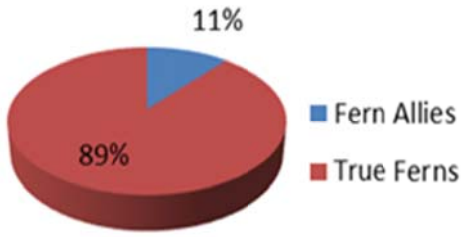

Fig. 3: Pteridophyte composition of Brgy.Tumpagon Cagayan de Oro City, Philippines.

The true ferns are generally composed of the endangered *C. contaminans and* the Least Concern *D. esculentum.* The conservation status of the rest of the Pteridophytes was not yet assessed by the IUCN. All of the species are classified as Widely Distributed since it is present in more than one location outside the Philippines.

Table 1 show that 17 of the Pteridophytes are economically important with five different economic qualifications. As shown in Fig. 4, Most (8) are identified with medicinal value; are edible (6); used as ornamental (6); and for handicrafts (4). Only 2 are classified as weeds. These identified economic species can be harnessed and mass propagated as environmentally sound source for alternative livelihood among miners of the locality.

Table 1: Species profile of pteridophytes found outside and inside the mining area

FAMILY NAME	SCIENTIFIC NAME	CONSERVATION STATUS/DISTRIBUTION/ ECONOMIC CATEGORY
1. ASPLENIACEAE	Asplenium nidus L.	Not assessed /Widespread/Ornamental; medicinal
2. ATHYRIACEAE	Diplazium esculentum	Least concern/widespread/ edible; medicinal
3. BLECHNACEAE	Blechnum orientale L.	Not assessed/ widespread/ edible; medicinal
4. CYATHEACEAE	Cyathea contaminans (Wall.ex Hook) Copel.	Endangered/Widespread/None
	Sphaeropteris glauca (Bl.) R. M. Tryon	Not assessed/Widespread/None
5. DAVALLIACEAE	Davallia solida (G. Forster) Swartz	Not assessed/Widespread/Ornamental
6. GLEICHENIACEAE	Dicranopteris linearis (Burm. F.) Underw.	Not assessed/Widespread/Handicraft; medicinal
	Gleichenia vulcanica Blume	Not assessed/Widespread/None
7. LINDSAEACEAE	Odontosoria chinensis (L.) J.Sm.	Not assessed/Widespread/None
8. LOMARIOPSIDACEAE	Cyclopeltis crenata (Fee) C.Chr.	Not assessed/Widespread/None
9. LYCOPODIACEAE	Lycopodiella cernua (L.) Pic. Serm.	Not assessed/Widespread/None
10. LYGODIACEAE	Lygodium circinnatum (Burm._f.)_Sw._	Not assessed/Widespread/ Edible; handicraft; medicinal
	Lygodium flexousum (L.) Sw.	Not assessed/Widespread/Edible; handicraft
	Lygodium japonicum (Thunb.)_Sw.	Not assessed/Widespread/Edible; handicraft
	Lygodium microphyllum (Cav.)_R._Br.	Not assessed/Widespread/Edible; handicraft
11. MARATTIACEAE	Angiopteris palmiformis (Cav.) C. Chr.	Not assessed/Widespread/Edible; Ornamental
12. NEPHROLEPIDACEAE	Nephrolepis biformes	Not assessed/Widespread/None
	Nephrolepis biseserata	Not assessed/Widespread/ornamental
	Nephrolepis cordifollia (LPresl.) C.	Not assessed/Widespread/medicinal
13. POLYPODIACEAE	Christopteris sagitta (Baker) Christ	Not assessed/Widespread/ widespread/
	Drynaria quercifolia	Not assessed/Widespread/ornamental; medicinal
	Microsorum punctatum (L.) Copel_	Not assessed/Widespread/Ornamental; medicinal
	Pyrrosia piloselloides (L.) M.G. Price	Not assessed/Widespread/medicinal
	Pyrrosia nummularifolia (Sw.) Ching	Not assessed/Widespread/None
14. PTERIDACEAE	Antrophyum reticulatum (G. Forst.) Kaulf.	Not assessed/Widespread/None
	Pityrogramma calomelanos (L.) Link	Not assessed/Widespread/None
15. SELAGINELLACEAE	Salagenella delicatula	Not assessed/Widespread/None
	Selaginella cupressina (Willd.) Spring.	Not assessed/Widespread/None
	Selaginella ornata (Hook. & Grev.) Spring	Not assessed/Widespread/None
16. TECTARIACEAE	Pleocnemia macrodonta	Not assessed/Widespread/None
	Tectaria aurita (Sw.)	Not assessed/Widespread/None
	Tectaria decurrens (C.Presl.) Copel.	Not assessed/Widespread/None
17. THELYPTERIDACEAE	Christella parasitica H.Lev.	Not assessed/Widespread/weed
	Pronephrium asperum (C.Presl.) Holttum	Not assessed/Widespread/None
	Pronephrium rhombeum Holttum	Not assessed/Widespread/None
	Sphaerostephanos unitus (L.) Holttum	Not assessed/Widespread/weed; medicinal

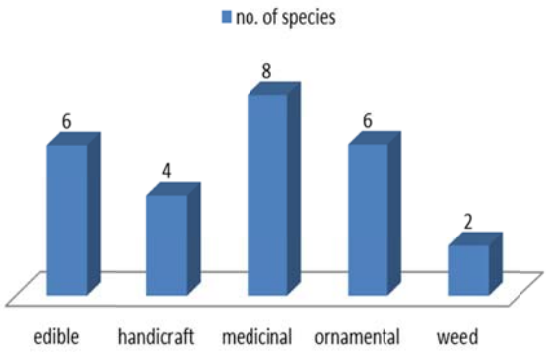

Fig. 4: Economic Classification of Pteridophytes in Tumpagon Cagayan de Oro City.

The seriation of transects (Fig. 5) shows the distribution of Pteridophytes inside and outside the mining area of Tumpagon, Cagayan de Oro City. The endangered *C. comtaminans* is present in all transects. According to Zamora and Co (1986), Cyathea species thrives in open areas, a habitat characteristic which is observed in all of the transects. The data further reveal that 6 species of Pteridophytes namely: *O.chinensis, N. biformes, P.calomelanos*, *B.orientale, L.cernua* and *G. vulcanica* are found only inside the mining area. These species seemed to thrive in open an area which is also the characteristic of the mined site. On the other hand, 18 species of Pteridophytes are present outside the mining site only, which include *P. rhombeum, C.*

saggita, M. punctatum, D. solida, S. ornata, S. cupressina, L. circinatum, P. nammularifolia, S. delicatula, P. piloselloides, A. palmiformes, A. nidus, C. parasitica, A. reticulatum, T. decurrens, T. aurita, and C. crenata. The removal of the surface soil due to hydraulicking technique adopted by the miners could be the reason for the absence of some Pteridophytes species inside mining area. Further, the same mining process also eliminate the trees which serve as habitat for such epiphytic pteridophytes under the families Polypodiaceae, Davalliaceae, Aspleniaceae, and Vittariaceae (Dixit, 2000).

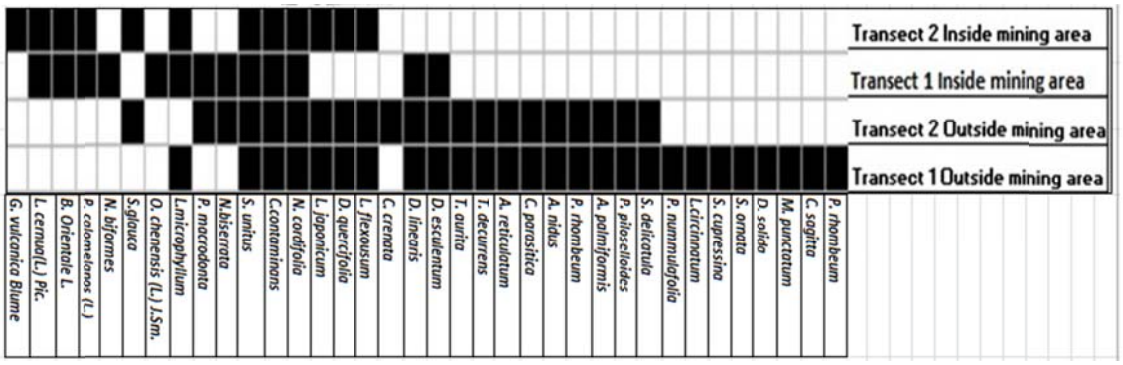

Fig. 5: Seriation of transects in Tumpagon, Cagayan de Oro City Philippines

The comparison of diversity indices in Table 2 shows that in terms of species richness, there is more number of species outside the mining area than inside; consistently it has more individuals outside than inside. Computation of Shannon's index, and Simpson's diversity revealed higher diversity values outside of the mining area. The slightly higher values obtained from the computed evenness and dominance inside the mining area could have been influenced by the presence of *N. cordiifolia* and *G. vulcanica* colonies. The lower value of diversity indices inside the mining area could be a result of mining activities which has a direct impact on the existing vegetation particularly surface mining which displaced or removed the existing plant cover since the topsoil are totally taken away (Lloyd et al., 2002).

Table 2: Diversity indices of pteridophytes found outside and inside the mining area of Brgy. Tumpagon, Cagayan de Oro, Philippines

DIVERSITY INDICES	INSIDE MINING AREA	OUTSIDE MINING AREA
Species Richness	18	30
Individuals	460	519
Dominance_D	0.337	0.291
Shannon_H'	0.967	1.482
Evenness_e^H/S	0.655	0.764
Simpson_1-D	0.511	0.708

4. Conclusion

The results of this study revealed that there are minor differences in the diversity of Pteridophytes in Brgy. Tumpagon, Cagayan de Oro City. However, the reduction of the number of species inside the mining area has contributed to the reduction brought about by habitat loss and degradation of the land. Surface mining is the main factor considered to be responsible for the reduced diversity of Pteridophytes inside the mining area.

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