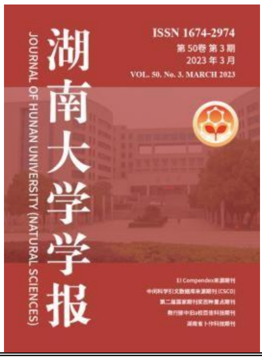

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Water quality determination using soil and vegetation communities in the wetlands of the Andes of Ecuador

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Abstract: The bofedales are high Andean ecosystems of great socioeconomic and ecological importance. The Chimborazo Fauna Production Reserve has 16 wetlands in its jurisdiction, located in the provinces of Chimborazo, Bolívar, and Tungurahua. The objective of this study was to establish the relationship between plant species composition and the physicochemical characteristics of water and soil. To determine the floristic composition, destructive sampling of species was applied, and three sampling points of 1 m^2 were established every 100 m per wetland. At each sampling point, physical-chemical variables were recorded in situ and in the laboratory for water and soil. The floristic analysis identified 79 riparian species (62 vascular *sp*, 12 bryophytes, 4 pteridophytes and 1 lichen). In the aquatic environment, 7 vascular plants, recognized as macrophytes, were recorded. The results show a great heterogeneity in the soil, water and vegetation characters, because they respond to a mineralization gradient (as indicated by the high values of electrical conductivity and dissolved ions). Phosphorus, sulfate, and particle size <0.1 were negatively correlated with oxygen and chemical demands, as does pH with NH4 in water and soil. The Casa Condor wetland is distinguished from the other wetlands by having the highest values for Calcium, Magnesium, Phosphorus, Organic Matter, Nitrates, Nitrites, Total Suspended Solids, and particle size > 0.2, 1, 0.5, which are shared with the Condor Samana BI and Pampa Salasaca BI wetlands. Consequently, it is imperative to double efforts to describe the ecology and status of these high Andean wetlands in order to promote their conservation.

Keywords. Floristic inventory, HJ-Biplot, Soil sampling, Vegetation communities, Water quality

利用厄瓜多尔安第斯山脉湿地的土壤和植被群落测定水质

摘要： 波费达莱
是安第斯高原的高山生态系统，具有重要的社会经济和生态意义。奇姆博拉索野生动物保护区在其管辖范围内拥有16个湿地，位于奇姆博拉索 玻利瓦尔 和通古拉瓦

省。本研究的目标是建立植物物种组成与水土物理化学特性之间的关系。为了确定植物群落组成，采用破坏性取样方法，每个湿地每100米设置3个1平方米的采样点。在每个采样点，记录水和土壤的原位和实验室物理化学变量。植物群落分析鉴定出79种河岸植物物种（62种维管植物、12种苔藓植物、4种蕨类植物和1种地衣）。在水环境中，记录到7种被认为是大型植物的维管植物。结果显示土壤、水和植被特征具有很大的异质性，因为它们对矿化梯度的响应（如高电导率和溶解离子的高值）。磷、硫酸盐和粒径
与氧气和化学需氧量呈负相关，与水和土壤中的氨态氮呈负相关。卡萨康多尔湿地以钙、镁、磷、有机物质、硝酸盐、亚硝酸盐、总悬浮物和粒径>的最高值而与其他湿地区别开来，这些特征也与康多尔萨马纳和潘帕萨拉萨卡BI（湿地共享。因此，迫切需要加倍努力描述这些安第斯高山湿地的生态和状况，以促进其保护。

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1. Introduction

There is now an urgent need to identify strategies for the preservation, restoration, and management of ecosystems (Beller et al., 2020). Population growth, expansion of the agricultural and livestock frontier, and industrial development worldwide are exerting strong pressures on natural ecosystems, especially aquatic ecosystems (Allan, 2004; Sánchez et al., 2007).

Wetlands are highly productive ecosystems (Withey and van Kooten, 2011; Xia et al., 2017) and comprise 8.5% of the Earth's land surface (Finlayson et al., 1999). They cover a total area of 12.1 million km^2 and account for 40.6% of the total value of ecosystem services (ES) (Costanza et al., 2014; Ramsar Convention on Wetlands, 2018).

The 1999 wetland classification of the Ramsar Convention identifies wetlands as non-forested peatlands (Blanco & de la Balze 2004). Their main functions include water pollution treatment, biogeochemical cycling adjustment, drought control and climate change mitigation (Moreno-Mateos et al., 2012) and contribution to the Earth's sustainability (Costanza et al., 1997; Junk et al., 2013). The ecological characteristics of these ecosystems are grouped into components, functions, and properties (Barbier, et al., 1997); the components being biotic and abiotic conditions, such as soil, water, and animals (Bragazza et al., 2005; Sottocornola et al., 2009; Glina et al., 2019), so they tend to be very dynamic with constantly changing energy reserves (Gallant, 2015).

The wetlands of the Andean tropics are in the high Andes Mountain range, at an altitude of more than 3,000 masl (Buytaert et al., 2006). In Ecuador, there are 13 Ramsar wetlands (Flachier et al., 2009) and 59 peatland-type ecosystems (known as bofedales in the Ecuadorian Andes) covering an area of 286,659 hectares and distributed throughout the continent (Jara et al., 2019), most of which are in protected areas that seek to conserve biodiversity (Guo et al., 2019). The coverage of terrestrial protected areas is increasing every year and currently cover just over 15% of the land area (Geldmann et al., 2015; UNEP-WCMC and IUCN, 2018). In Ecuador, protected areas represent approximately 20% of the national territory (Ministry of Environment of Ecuador, 2014).

The Chimborazo Fauna Production Reserve (RPFCH) is part of the National System of Protected Areas of Ecuador, located in the provinces of Chimborazo, Bolivar, and Tungurahua (MAE, 2014). Altitudes in the Reserve ranges from 3,800 to 6,310 meters above sea level (MAE, 2014).

The RPFCH covers 58,560 hectares (Jara et al., 2019; McLaren et al., 2018), of which 39% are wetland-type ecosystems: 24% of the wetland ecosystem is in the intervened category, 12% is moderately conserved, while the remaining 3% is conserved (Jara et al., 2019). The main ecosystem services of peatlands include water regulation, water supply and carbon storage (Castro, 2011).

Abiotic conditions, such as soil, plants, hydrology, and water chemistry, are the decisive factors in the pattern of wetland ecology (Bragazza et al., 2005; Sottocornola et al., 2009; Hill et al., 2016; Nicia et al., 2018; Glina et al., 2019; Griffiths et al., 2019). Plants are the main primary producers, playing an important role in the maintenance and stability of these ecosystems (White et al., 1978; Simas and Ferreira, 2007). Submerged wetland plants (macrophytes) provide a variety of ecological functions and services, such as providing substrate for algae and invertebrates (van Donk and van de Bund, 2002) and influencing biogeochemical cycles and productivity (Wetzel and Hough, 1972). However, plants, like other components of aquatic ecosystems, currently face increasing anthropogenic threats (Zhang et al., 2017).

Several studies have shown that soil nutrients are one of the main factors affecting plant productivity (Gong and Gao, 2019). Changes in the types and variations of plant functional traits (Carreño-Rocabado et al., 2016; Chillo et al., 2018) are decisive factors in the regulation of soil functions (Peco et al., 2017), because coexisting species with contrasting trait values increase overall resource acquisition and use through complementary niche effects (Diaz et al., 2007; Wen et al., 2019). The loss of plant species diversity caused by changes in land-use intensity leads to a reduction in individual soil functions, such as soil nitrogen and water retention (Fischer et al., 2018; Klaus et al., 2018).

For some time, researchers have been trying to determine the influence of vegetation cover on soil and water conditions (Villegas, 2004). In this study, we evaluate the existing relationships between the biotic and abiotic components of peatlands or bofedales located in the Chimborazo Fauna Production Reserve (RPFCH), in the Ecuadorian Andes: plant-water-soil, thus understanding the correspondence between vegetation and environment, which allows us to provide information for the spatio-temporal simulation of these ecosystems and thus develop programs for the protection and proper management of peatlands.

2. Materials and methods

a. Study area

The study was conducted in 16 bofedales of the RPFCH in the interior of the Andes, with a temperature ranging from –3 to 14°C and an average annual precipitation of 1000 mm, with a humidity percentage of 70–85% (MAE, 2014). The vegetation cover is formed by mixed natural communities of peatlands, sporadic water quinielas and buffer vegetation, resulting in a deep and peaty organic soil. The bofedales are located between 3825 and 4240 masl in the provinces of Bolivar (6 bofedales), Chimborazo (4 bofedales) and Tungurahua (6 bofedales), where they cover areas ranging from 2 to 155 ha (Annex 1; Fig. 1).

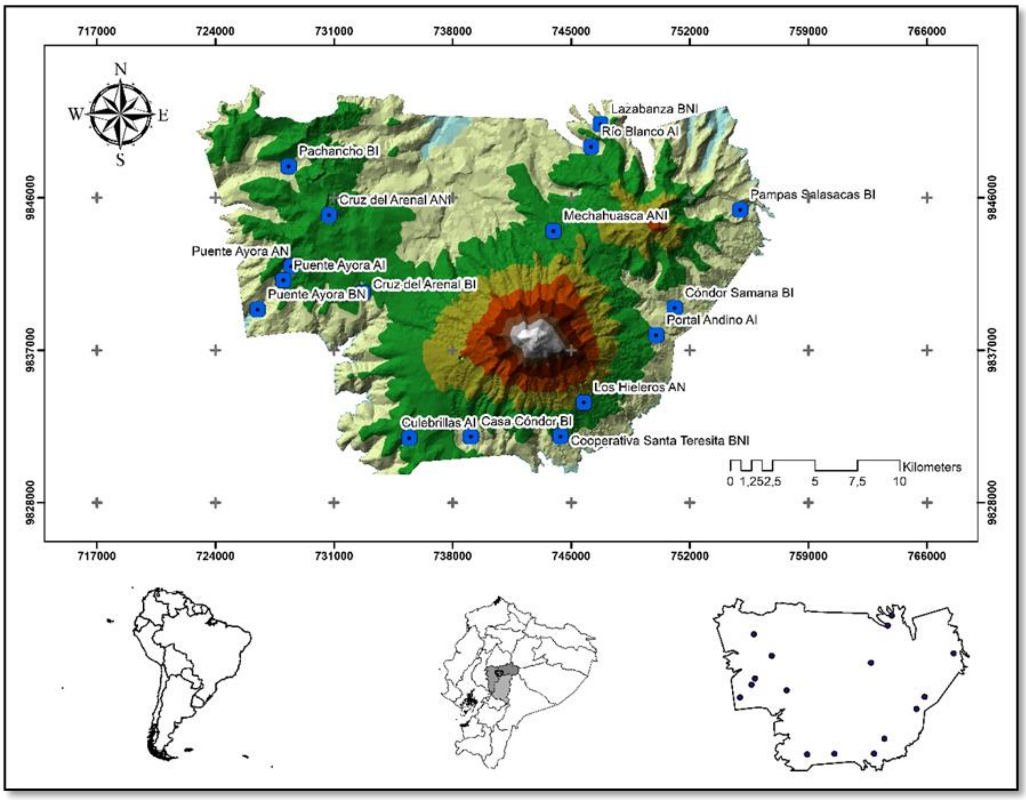

Figure 1. Geographic location of the wetlands of the RPFCH (BNI: Low Intervened Level. BI: Low Intervention. AI: High Intervention. ANI: High Intervened Level; according to Andrade, 2016).

b. Floristic sampling and inventory

Field work was carried out in September 2018 and February 2019. Sampling units were distributed for each bofedal: point one (P1) in the upper zone of the bofedal, point two (P2) in the intermediate zone and point three (P3) in the lower zone of the bofedal. They were then georeferenced (appendix 1) using a GARMIN OREGON 650 GPS. Plots of 1 m^2 (Matteucci and Colma, 1982) were established along the slope of the bofedales between 3825 and 4240 masl. A total sweep was made within the plot, considering the edge error, and keeping the conditions within the unit intact, to carry out subsequent measurements. Species identification was carried out in two authorized herbariums in Ecuador: The Herbarium of the Department of Biological Sciences of the Pontificia Universidad Católica del Ecuador in Quito (QCA Herbarium) and the Herbarium of the Escuela Superior Politécnica de Chimborazo (CHEP).

Regarding to measurement of selected physicochemical variables, collection, and analysis of water samples. All measurements and water sample collection were performed randomly in duplicate, in each wetland two liters of water were taken. Values of pH, temperature (^{o}C), dissolved oxygen, DO (mg/L) and electrical conductivity, EC (µS/cm), were measured on site, using a pH meter (PC-PH22), a portable oximeter (HANNA HI9146-04) and a portable multiparameter probe Crison MM40.

Water samples (2 L each) were collected using glass bottles (1000 mL) and placed in portable coolers at –10°C without preservatives. They were then sent to the Water-Industrial Effluents Environmental Analysis Laboratory (LASA-Quito) to be analyzed according to the standard method (APHA, 1999). The samples analyzed were: pH; Temperature (Temp., °C); Ammonium (NH4., mg/l), Calcium (Ca., mg/l), Electrical conductivity (Cond., uS/cm), Biological oxygen demand (BDO., mg/l), Chemical oxygen demand (C.O.D., mg/l), Hardness (mg CaCO3 / l), Phosphorus (P., mg/l), Magnesium (Mg., mg/l), Nitrates (mg / l), Nitrites (mg / l), Dissolved oxygen (Diss. O., mg / l and %), Totally suspended solids (TSS, mg / l) and sulfates (mg / l).

c. Soil sampling and analysis

A two-dimensional sampling was performed since peatlands have an irregular shape of less than 1000 m^2. Six samples were taken / peatland, the distribution per sample was 1 every 15 linear meters (4) and at the bottom of the peatland (2) at a depth of 30 cm (Ramirez, 1990). A total of 96 samples were collected for analysis of granulometry and organic matter. The samples were collected in wide-mouthed glass jars with lids and Teflon seals and transported to the Soil Laboratory of the Faculty of Natural Resources of the Escuela Politécnica Superior del Chimborazo where they were analyzed following the methodology of the Soil Analysis Manual of the Soil Laboratory Network of Ecuador (RELASE, 2001).

d. Data analysis

Statistical analyses on floristic and physical composition of Wetland soil and water chemistry data were performed using R statistical software (R Core Team, 2020). To detail the key variables explaining the high variability in the dataset, Principal Component Analysis (PCA; Wold et al., 1987) with the packages FactoMineR (Husson et al., 2007) and ggbiplot (Wickham, 2011) were applied to standardized soil and water variables. This allowed for the selection of physicochemical variables (e.g., pH, NH4, dissolved oxygen, suspended solids) and physical habitat attributes, while reducing the dimensionality of the data set. Biplots were made for the first two components based on the resulting scores and loadings that provided an overview of the relationships between multiple variables and sites with the highest level of intervention within the protected area (Muriithi and Yu, 2015; Jabbar and Grote, 2019).

A canonical correspondence analysis (CCA) (Ter Braak and Verdonschot, 1995) was conducted to elucidate relationships between biological assemblages of species and their environment. For the scope of the study, the effect of water and soil variables on vegetation was compared using the vegan package (Oksanen et al.2017). A direct selection of explanatory variables was calculated, and the significance of the CIC results was tested by permutation.

A non-metric multidimensional scale (NMDS; Holland, 2008) was used, to calculate only a limited number of axes explicitly chosen prior to analysis (sample sites - intervention level), based on Bray-Curtis distances (Beals, 1984) of vegetation composition to compare sites, using metaNMDS function of the vegan package. With an integrating approach and with the desire to obtain greater discrimination of the data, the HJ-Biplot (Galindo, 1985) multivariate analysis was carried out in MultBiplot Software.

Biplot analysis is a procedure for the simultaneous graphic representation of the rows and columns of a matrix, which allows summarizing the information of a matrix of rank r in a space of dimension q, less than r. The Biplot that absorbs the greatest possible information, in terms of variability, of a matrix X, of rank r, is the one corresponding to the matrix $X_{[q]}$ of rank *q*, which constitutes the low-rank approximation of X, which is obtained from the decomposition in singular values of X (Eckart and Young 1936) as:

$$X_{[q]} = U_{(q)} D_{(q)\lambda} V_{(q)}^{T}$$

where U (q) is the matrix, whose columns contain the first *q* eigenvectors of XX^T, $D_{(q)\lambda}$ is the diagonal matrix with the first *q* singular values of X, and $V_{(q)}$ is the matrix containing the *q* first eigenvectors of X^TX. This expression also corresponds to the singular value decomposition of $X_{[q]}$. There are two classic options to achieve better quality representation of either the columns (GH) or the rows (JK).

Galindo (1985, 1986) proposes taking $A = U_{(q)} D_{(q)\lambda}$ *y* $B = D_{(q)\lambda} V_{(q)}^{T}$. The Biplot thus constructed was called HJ-Biplot by its author, respecting the logic of the names proposed by Gabriel 1971. Its main characteristic is that both the rows and the columns reach the highest quality of representation. In this case, it is obvious that the internal product of the vector markers will not reproduce the data of the starting matrix, even retaining the *q* dimensions. However, this is not a problem, since the objective is generally not to reproduce the original data, but to obtain a simultaneous approximation of the rows and columns of X in which both are well represented.

3. Results

Floristic inventory

The floristic inventory (Table 1) identified 86 plant species, of which 73 species (85%) are vascular and 13 species (15%) are non-vascular.

Only seven of the species (7.5%) have aquatic characteristics. The most abundant family was Asteraceae with 15 species, Poaceae with 7 species and Apiaceae with 5 species among the most representative. The greatest percentage of the species identified (85%) are native, with a distribution area restricted to the moorlands of the center and south of the country; the place of origin of 7% of the species could not be identified; 4% of the species have been introduced in the areas; while the remaining 4% are endemic species of the country: *Halenia pulchella*, *Gnaphalium chimboracense* and *Nototriche hartwegii*, the same ones that according to the Red Book of Endemic Plants of Ecuador (2019), are in states of least concern (with a population number of 30), vulnerable (with a population number of 2) and the last one in endangered status (with a population number of 2), respectively.

Table 1. Wetland plants of the Chimborazo Fauna Production Reserve.

PHYLLUM	CLASS	ORDER	FAMILY	CIENTIFIC NAME	COMMON NAME	ORIGEN
Ascomycota	Lecanoromicetos	Lecanorales	Sphaerophoraceae	*Bunodophoron melanocarpum* (Sw.) Miércoles, 1995	Licuar	SI
Bryophyta	Bryopsida	Bartramiales	Bartramiaceae	*Breutelia chrysea* (Müll. Hal.) A. Jaeger, 1875	Musgo	Native
				*Bartramia potosica*Mont, 1838	Musgo	Native
		Bryales	Bryaceae	*Rhodobryum* (Schimp.) Limpr, 1892	Musgo	SI
			Mniaceae	*Plagiomnium rhynchophorum* (Gancho) TJ Kop, 1971	Musgo	Native
		Hypnales	Brachytheciaceae	*Brachythecium austroglareosum* (Müll. Hal.) Kindb, 1891	Musgo	Native
			Thuidiacea	*Thuidium peruvianum*Mitt, 1869	Musgo	Native
		Hookeriales	Pilotrichaceae	*Cyclodictyon roridum* (Hampe) Kuntze, 1891	Musgo	Native
		Pottiales	Pottiaceae	*Leptodoncio longicaule*Mitt, 1869	Musgo	Native
				Leptodoncio ulocalix (Müll. Hal.) Mitt, 1869	Musgo	Native
				Leptodoncio wallisii (Müll. Hal.) Kindb, 1888	Musgo	Native
Marchantiophyta	Marchantiopsida	Marchantiales	Marchantiaceae	*Marchantia*L, 1753	Alga	SI
	Jungermanniopsida	Porellales	Lejeuneaceae	*Lejeunea*Lib, 1820	S / N	Native
	Equisetopsida	Lycopodiales	Lycopodiaceae	*Huperzia crassa* (Humb. Y Bonpl. Ex Willd.), 1944	Cacho de venado	Native
		Cyatheales	Cyateaceae	*Alsophila R. Br,* 1810	Helecho	SI
		Polypodiales	Dryopteridaceae	*Elaphoglossum*engelii (H. Karst.) Cristo, 1899	Lengua de venado	Native
				Polystichum orbiculatum (Desv.) J. Rémy & Fée, 1853	Helecho	Native
			Polypodiaceae	*Melpomene moniliformis* (Lag. Ex Sw.) AR Sm. Y RC Moran, 1992	S / N	Native
		Equisetales	Equisetaceae	*Equisetum*bogotense Kunth, 1815	Cola de caballo	Native
		Efedrales	Ephedraceae	*Efedra*rupestris Benth, 1846	Sanu sanu	Native
		Alismatales	Hydrocharitaceae	*Elodea canadensis*Rich, 2007	Peste de agua	Native
			Potamogetonaceae	*Potamogeton filiformis* Pers, 1805	S / N	Native
		Poales	Cyperaceae	*Eleocharis dombeyana* Kunth, 1837	Junco falso	Native
				Carex bonplandii Kunth, 1837	Juncia	Native
				*Eleocharis albibracteata*Nees y Meyen ex Kunth, 1837	Quilmen	Native

		Juncaeae	*Distichia muscoides* Nees y Meyen, 1843	Waricha	Native
		Poaceae	*Agrostis foliata*Hook, 1844	Paja de páramo	Native
			Agrostis breviculmis (J. Presl) Hitchc, 1905	Paja enana	Native
			*Bromus pitensis*Kunth, 1816	Bromo, triguillo	Native
			Cortaderia sericantha (Steud.) Hitchc, 1927	Cortadeira	Native
			Eragrostis nigricans (Kunth) Steud, 1840	Grama piojos	Native
			Muhlenbergia angustata (J. Presl) Kunth, 1833	Tempela	Native
			*Phalaris minor*Retz, 1783	Pasto	Introduced
	Apiales	Apiáceas	*Azorella*pedunculata (Spreng.) Mathias y Constance, 1995	Tumpusu	Native
			*Eryngium*humile Cav, 1860	Cardon Santo	Native
			Oreomyrrhis andicola (Kunth) Gancho. F, 1846	Pampa cominos	Native
			Azorella biloba (Schltdl.) Miércoles, 1860	Yareta	Native
			Azorella aretioides (Spreng.) Willd. ex DC, 1830	Almohadilla	Native
	Asterales	Asteraceae	*Baccharis caespitosa* (Ruiz y Paul) Pers, 1807	Romerillo	Native
			*Bidens*andicola Kunth, 1820	Nachay	Native
			Achyrocline alata (Kunth) DC, 1837	Lana de perro	Native
			*Gamochaeta*americana (Mill.) Miércoles, 1855	Lancetilla, lechugilla	Native
			*Gnaphalium*spicatum (Forssk.) Vahl, 1788	Lengua de perro	Native
			*Hypochaeris*sessiliflora Kunth, 1820	Santamaría, patuda	Native
			*Monticalia*arbutifolia (Kunth) C. Jeffrey, 1992	S / N	Native
			*Oritrofio*peruvianum (Lam.) Cuatrec, 1961	Uña kushma	Native
			*Werneria*nubigena Kunth, 1820	Chicoria	Native
			Xenophyllum humile (Kunth), 1997	Almoadilla	Native
			*Erigeron ecuadoriensis*Hierón, 1896	Copo negro	Native
			Erigeron L, 1753	S / N	SI
			Culcitium Bonpl, 1808	S / N	SI
			*Gnaphalium purpureum*L, 1753	ceto ceto	Native
			*Gnaphalium chimborazense*Hierón, 1900	S / N	Native
	Brassicales	Brassicaceae	*Rorippa pinnata* (Sessé y Moc.) Rollins, 1960	Berro	Native

Cariofilales	Caryophyllaceae	*Drymaria*ovata Humb. & Bonpl. ex Schult, 1819	Drymaria	Native
	Poligonáceas	*Rumex*acetosella L, 1753	Alfarito	Introduced
Ericales	Ericaceae	*Disterigma*empetrifolium (Kunth) Drude, 1889	Nigua, manzanita	Native
		*Pernettya*prostrata (Cav.) Sleumer, 1935	Mortiño, moridera	Native
		*Vaccinium floribundum*Kunth, 1819	Manzana, manzanilla	Native
Gentianales	Gentianaceae	*Gentiana cerastioides*Kunth, 1819	Flor de novios	Native
		*Gentiana*sedifolia Kunth, 1819	Kuyana, amor sacha	Native
		Gentianella corymbosa (Kunth) Weaver y Ruedenberg, 1975	Gentianela	Native
		*Halenia pulchella*Gilg, 1916	Cacho de venado	Endemic
	Rubiaceae	*Hipocarpio de galio* (L.) Endl. ex Griseb, 1864	Achotillo, coralito	Native
		*Galium pumilio*Standl, 1929	S / N	Native
		Nertera granadensis (Mutis ex L. f.) Druce, 1916	Coralito, tomatillo	Native
Geraniales	Geraniaceae	*Geranio*diffusum Kunth, 1821	Agujilla	Native
Fabales	Fabaceae	*Lupinus microphyllus* Desr, 1792	Sacha chocho	Native
		*Lupino*pubescens Benth, 1845	Urku Chocho	Native
		*Trifolium*repens Walter, 1753	Trebol blanco	Introduced
Saxifragales	Haloragaceae	*Myriophyllum quitense*Kunth	Colas de caballo	Native
Malpighiales	Hypericáceas	*Hypericum laricifolium*Juss, 1804	Romerillo	Native
Malvales	Malváceas	*Nototriche hartwegii*AW Hill, 1909	S / N	Endemic
Lamiales	Orobanchaceae	*Bartsia*laticrenata Benth, 1989	S / N	Native
		*Castilleja*fissifolia L. f, 1995	Flor del quinde	Native
	Plantaginaceae	Sibthorpia repens (L.) Kuntze, 1819	Ukucha rinri	Native
		*Plantago*australis Lam, 1791	Llanten de páramo	Native
		Plantago rigida Kunth, 1817	Almohadilla	Native
Myrtales	Onagráceas	*Epilobium denticulatum*Ruiz y Pav, 1802	Urku Shullu	Native
Ranunculales	Ranunculaceae	*Ranunculus peruvianus*Pers, 1806	Urku nabo	Native
		*Ranunculus flagelliformis*Sm, 1815	Cuchara Kullki	Native

	Rosales	Rosáceas	*Lachemilla andin*a (LM Perry) Rothm, 1937	Pirín blanco	Native
			Lachemilla galioides (Benth.) Rothm, 1938	Orejuelas	Native
			Lachemilla orbiculata (Ruiz y Pav.), 1908	Plegadera, Oreja de ratón	Native
	Dipsacales	Valerianaceae	*Valeriana*microphylla Kunth, 1818	Valeriana	Native
			*Valeriana*rigida Ruiz y Pav, 1798	Valeriana	Native

SI: Unidentified

Physicochemical analysis of water

Most of the physicochemical variables (Table 2) showed variations between groups and differed by more than one or two orders of magnitude. The TULSMA mentions that the established value for this parameter should be between 6.5 and 9.0 pH units; in this study, all the samples analyzed met this value, remaining in the neutral range and demonstrating the absence of substances that could affect it. The water temperature at the sampling sites ranged from 7 to 11°C (45 to 52°F). Ammonium concentrations differed greatly in the wetlands in amounts varying between 0.05 and 9.9 (mg/l), calcium (Ca., mg/l) ranged between 1 and 20 (mg/l). Conductivity remained in the range of 14-289 (µS/cm), being the highest reported in the Casa Condor BI wetland. The concentrations of the chemical parameters, nitrate remained in a range < 0.70 (mg/L) during the study period. Nitrite values were less than 0.002 (mg/L). Dissolved oxygen concentrations were between 6 and 7 (mg/L) which corresponded to elevated B.O.D. concentrations.

Concentrations of nutrients that potentially limit primary production such as phosphorus (p) and nitrates were very low and in many cases below the detection limit (less than 0.01 mg/l in 75% of the cases for total phosphorus and 93% for nitrates (Table 2). According to our physicochemical data, most of the bogs can be considered miner trophic peatlands (Heinselman 1970; Verhoeven et al., 1990; Miserere et al., 2003).

Table 2. Physico-chemical analysis of the water of the RPFCH wetlands.

Wetland	**pH**	**Temp (°C)**	**NH4 (mg/l)**	**Ca (mg/l)**	**Cond. (uS/cm)**	**B.O.D. (mg/l)**	**C.O.D. (mg/l)**	**Hardness (mg CaCO3/l)**	**P (mg/l)**	**Mg (mg/l)**	**NO_3- (mg/l)**	**NO_2- (mg/l)**	**Diss. O. (mg/l)**	**Diss. O. (%)**	**T.S.S. (mg/l)**	**SO_4^{2-} (mg/l)**
Pampa Salasacas BI	7,7	9,7	0,30	8,69	91,60	3,80	27,69	40,68	0,025	4,62	0,00	0,005	6,45	99,70	60,00	9,60
Río Blanco AI	6,9	9,9	0,33	14,48	109,70	10,05	70,31	48,48	0,002	3,00	0,40	0,001	6,70	103,10	22,00	0,70

Mechahuasca ANI	7,3	7,7	0,17	8,23	87,00	8,85	79,48	37,26	0,005	4,08	0,40	0,001	6,36	97,60	25,00	0,60
Cruz del Arenal BNI	6,9	10,2	0,05	5,64	75,60	13	85,60	28,13	0,004	3,42	0,40	0,001	6,47	100,20	29,00	1,10
Cruz del Arenal ANI	7,4	9,7	0,08	6,31	94,50	0,74	6,11	36,08	0,008	4,94	0,30	0,003	6,49	100,70	7,00	1,10
Culebrillas AI	7,4	11,2	0,00	5,18	67,60	1,56	3,05	22,81	0,170	2,40	0,10	0,000	6,42	98,70	66,00	3,60
Casa Cóndor BI	7,4	7,9	0,08	20,95	209,00	5,15	21,40	101,70	0,001	12,01	0,50	0,006	6,27	96,30	19,00	11,50
Coop. Santa Teresita BNI	7,6	8,0	0,21	1,22	14,32	3,70	21,40	5,70	0,003	0,65	0,70	0,001	6,69	103,30	37,00	0,00
Lazabanza BNI	7,7	10,7	0,35	5,49	49,30	10,05	67,26	20,53	0,005	1,66	0,10	0,000	6,34	97,8	19,00	0,10
Cóndor Samana BI	7,4	11,3	0,08	8,76	143,50	1,80	27,69	69,39	0,001	11,55	0,70	0,001	6,65	102,80	36,00	0,90
Portal Andino AI	7,4	8,9	0,30	1,98	25,40	1,50	6,92	10,27	0,001	1,30	0,40	0,007	7,26	112,30	66,00	0,00
Los Hieleros ANI	7,6	8,8	2,17	2,36	16,57	1,48	17,31	7,98	0,310	0,51	0,00	0,013	7,00	108,00	215,00	0,00
Pachancho BI	7,1	9,1	0,95	15,00	178,50	3,00	76,43	85,40	0,000	11,66	0,50	0,000	6,34	99,10	4,00	0,10
Puente Ayora BNI	6,9	8,7	0,48	4,00	45,10	0,62	3,05	18,42	0,000	2,05	0,40	0,001	6,00	92,30	36,00	0,60
Puente Ayora AI	7,6	8,5	0,05	6,15	63,40	0,74	3,05	23,41	0,006	1,96	0,30	0,001	6,51	101,20	2,00	3,30
Puente Ayora ANI	7,1	8,6	0,18	9,54	97,90	0,26	3,05	41,84	0,220	4,39	0,40	0,000	6,11	93,09	7,00	0,30

Physicochemical Parameters: Temperature (Temp., °C); Ammonium (NH4., mg/l), Calcium (Ca., mg/l), Electrical conductivity (Cond., uS/cm), Biological oxygen demand (BDO., mg/l), Chemical oxygen demand (C.O.D., mg/l), Hardness (mg CaCO3 / l), Phosphorus (P., mg/l), Magnesium (Mg., mg/l), NO_{3-} (Nitrates., mg / l), NO_{2-} (Nitrites., mg / l), Dissolved oxygen (Diss. O., mg / l and %), Totally suspended solids (TSS, mg / l) and sulfates (mg / l).

Soil analysis

The variables analyzed show the values included in Table 3.

Table 3. Granulometry and organic matter analysis (indicate the meaning of each abbreviation).

Wetland	pH	Elec. Cond (uS)	Organic Matter (%)	NH4 (mg/kg)	P (mg/kg)	K (mg/kg)	Texture	Organic carbon (%)
Pampa Salasacas BI	5,10 L.Ac.	177,5 Non-saline	1,4 %	23,78 B	35,24 A	0,47 B	Free sand	0,81 %
Río Blanco AI	5,32 L.Ac.	285,0 Non saline	2,9 %	9,11 B	29,68 M	1., 12 A	Sandy loam	1,68 %
Mechahuasca ANI	5,37 L.Ac.	292,0 Non saline	2,6 %	27,95 B	25,96 M	0,57 M	Free sand	1,50 %
Cruz del Arenal BNI	5,97 L.Ac.	136,7 Non saline	1,1 %	7.26 B	38,02 A	0,36 B	Free sand	0,63 %
Cruz del Arenal ANI	5,65 L.Ac.	324,0 Non saline	5,0 %	15.60 B	27,12 M	0,65 A	Free sand	2,90 %
IA de Culebrillas	5,76 L.Ac.	217,0 Non saline	1,3 %	8,92 B	30,37 A	0,67 A	Free sand	0,75 %
Casa Cóndor BI	5,32 L.Ac.	603,0 Non saline	3,4 %	15,68 B	41.04 A	1,25 A	Free sand	1,97 %
Cooperativa. Santa Teresita BNI	5,66 L.Ac.	228,0 Non saline	1,8 %	10,09 B	34,32 A	0,99 A	Free sand	1.04 %
Lazabanza BNI	5,07 L.Ac.	214,0 Non saline	4,5 %	24,21 B	26,43 M	0,86 A	Free sand	2,61 %
Cóndor Samana BI	5,36 L.Ac.	149,1 Non saline	3,4 %	21,89 B	37,09 A	0,61 M	Free sand	1,97 %
Portal Andino AI	5,32 L.Ac.	140,6 Non saline	1,3 %	12,70 B	25,73 M	0,58 M	Free sand	0,75 %
Los Hieleros ANI	5,20 L.Ac.	231,0 Non saline	1,3 %	10,85 B	32,00 A	0,78 A	Free sand	0,75 %
Pachancho BI	5,66 L.Ac.	252,0 Non saline	2,5 %	11,47 B	49,62 A	1,21 A	Free sand	1,45 %
Puente Ayora BNI	5,44 L.Ac.	164,0 Non saline	3,7 %	21,78 B	30,84 A	0,78 A	Sandy loam	2.14 %
Puente Ayora AI	5,46 L.Ac.	197,7 Non saline	3,1 %	12,26 B	32,92 A	0,95 A	Sandy loam	1,79 %
Puente Ayora ANI	5,47 L.Ac.	223,0 Non saline	3,4 %	15,50 B	33,16 A	0,81 A	Sandy loam	1,97 %

Parameters: Elec. Cond: Electrical conductivity; % OM: Percentage of Organic Matter; NH4: Ammonium; P: Phosphorus: K: Potassium
Soil pH: slightly acidic (L.Ac.) Presence level: A: High; M: Medium; B: Low

Characterization of sites with soil and water variables

The first two principal components of the PCA with soil and water parameters accounted for 69.6% and 63.6% of the variation in the data, respectively. For the PCA with soil parameters, CO and texture had the lowest loadings in PC1, while K and P had the highest loadings in PC2 (Table 4). For the PCA with water parameters, total suspended soils and NO2 had the highest loadings in PC1, while Ca and pH had the highest and lowest loadings respectively in PC2.
The Casa Condor wetland presented the highest values of Ca, EC, Mg and SO42- in water, having the highest loadings in PC2 for the PCA with water parameters. In contrast, the wetlands of the Chambo River basin had the lowest levels of Ca, EC, Mg, SO42- and NO2-, and the highest values of dissolved oxygen and total suspended solids in water. The wetlands of the Pastaza basin had the highest NH4 + contents in soils.

Table 4. PCA variable loadings and variable contribution to the first two principal components of the PCAs constructed with soil and water variables.

Soil Variables	PC1 charges	PC2 charges	PC1 (%) contribution	PC2 (%) contribution
NH4	-0,379	-0,464	14.3	21,5
PAG	0,245	0.548	6.0	30,0
K	-0,294	0,665	8,6	44,2
Texture	-0,561	0,206	31,5	4.26
CO	-0,628	-0,002	39,5	0,0004
Eigenvalue	1.831	1.648	-	-

Water Variables	PC1 charges	PC2 charges	PC1 (%) contribution	PC2 (%) contribution
NH4	0,409	0.103	16,7	1.1
California	-0,186	0,635	3,4	40,2
PAG	0.357	0,002	12,7	0,0003
NUMBER 3	-0,293	-0,276	8,6	7,6
NO2	0,457	0,089	20,9	0,8
Dissolved oxygen	0.310	-0,399	9,6	15,9
TOTAL SUSPENDED SOLIDS (TSS)	0.485	-0,095	23,5	0,9
Ph	-0,213	-0,578	4.5	33,3
Eigenvalue	3.841	1.251	-	-

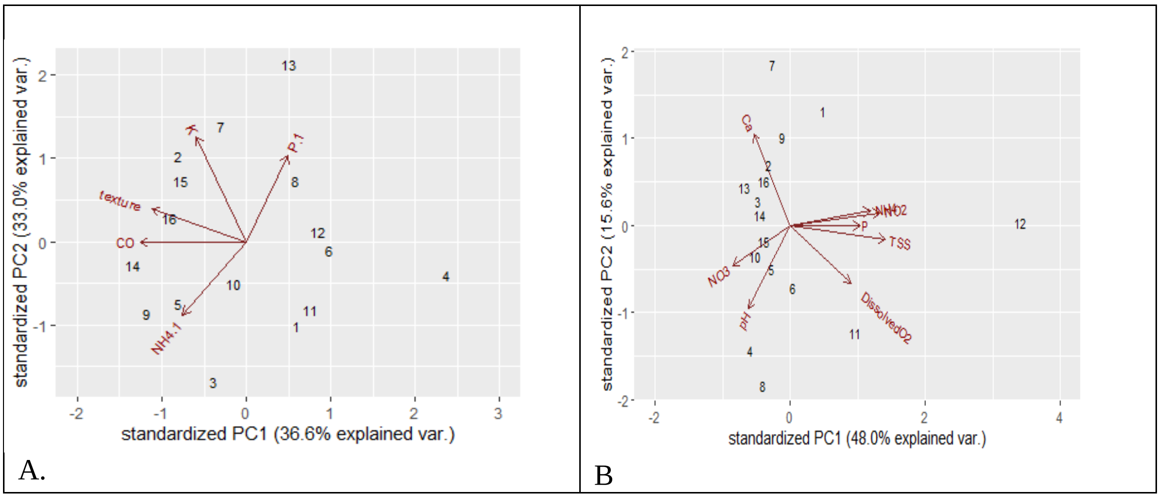

Figure 2. Principal component analysis (PCA) of soil (A) and water (B) variables. Arrows represent the variables involved. Abbreviations used for each wetland: 1 - Pampa Salasacas, 2- Rio Blanco, 3- Mechahuasca, 4 - Cruz del Arenal BNI, 5 - Cruz del Arenal ANI, 6 - Culebrillas, 7 - Casa Condor, 8-Coop Santa Terersita, 9-Lazabanza, 10- Condor Samana, 11- Portal Andino, 12 - Los Hieleros, 13- Pachancho, 14 - Puente Ayora BNI, 15 - Puente Ayora AI, 16- Puente Ayora ANI.

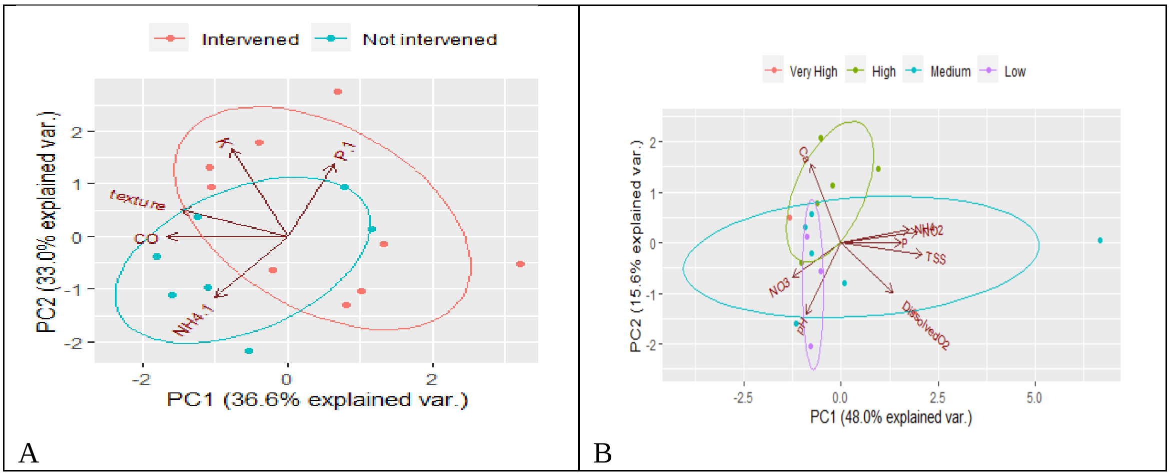

Figure 3. Principal component analysis (PCA) of soil (A) and water (B)

variables. Arrows represent the variables involved; circles represent the level of intervention.

In the PCA based on water characteristics, sites with higher level of intervention had higher PC2 values (B). In the PCA based on soil characteristics, intervened areas had higher values of PC2 and PC1 (A).

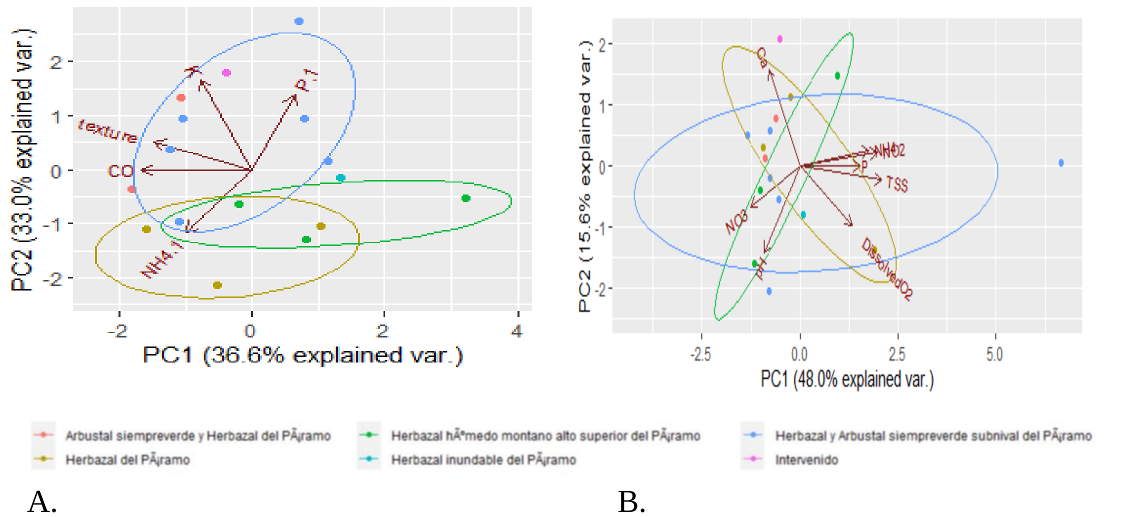

Figure 4. Principal component analysis (PCA) of soil (A) and water (B) variables. The arrows represent the variables involved; the circles represent the type of ecosystem.

The PCA based on soil characteristics differentiates three different ecosystem types studied-"Páramo grassland" had the lowest PC2 values, while "Páramo evergreen subnival grassland and shrubland" had the highest PC2 values and "Páramo upper montane moist upper montane grassland" had intermediate PC2 values (Fig. 4A). The PCA based on water variables did not clearly separate the different ecosystems (Fig. 4B).

Effect of environmental variables on the composition of bofedal vegetation

Bofedal vegetation was mainly affected by water properties; with P and NO2 being significant in determining vegetation composition in the CCA analysis (F-ratio = 1.925, p-value = 0.005) and together they explained 22.84% of the variability. For soil properties, none of them were significant determinants of vegetation composition.

The vegetation of Puente Ayora ANI was clearly differentiated from the other areas by the CCA analysis with water properties. (Fig. 5), with higher CCA1 and lower CCA2. Los Hieleros also had low CCA2, but lower CCA1.

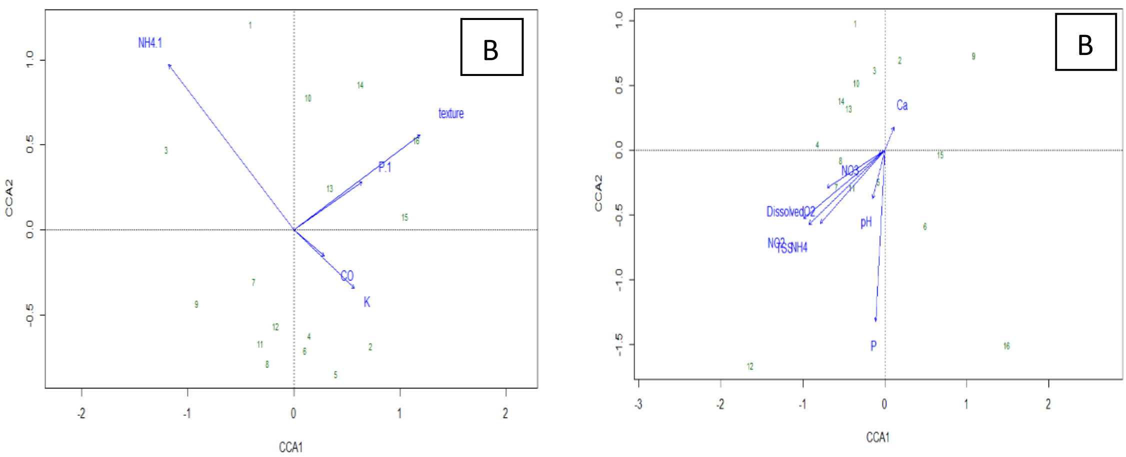

Figure 5. Canonical correspondence analysis (CCA) showing the relationships between bofedal plant composition and soil (A) and water (B) parameters. Abbreviations used for each bofedal: 1 - Pampa Salasacas, 2- Rio Blanco, 3- Mechahuasca, 4 - Cruz del Arenal BNI, 5 - Cruz del Arenal ANI, 6 - Culebrillas, 7 - Casa Condor, 8-Coop Santa Terersita, 9-Lazabanza, 10- Condor Samana, 11- Portal Andino, 12 - Los Hieleros, 13- Pachancho, 14 - Puente Ayora BNI, 15 - Puente Ayora AI, 16- Puente Ayora ANI.

Table 4. Canonical Correspondence Analysis (CCA) biplot scores for soil and water parameters and the first two canonical axes.

Soil Variables	Axis 1	Axis 2
NH4	-0,472	0.388
PAG	0,258	0,112
K	0,228	-0,136
Texture	0,476	0,222
CO	0.115	-0.060
Eigenvalue	0.565	0,426
Proportion explained	0.355	0,268

Water Variables	Axis 1	Axis 2
Temperature	0.337	0,170
NH4	0,006	-0,199
California	-0,199	0.052
Conductivity	-0,175	0.000
BOD	-0,210	-0,204
COD	-0,237	-0,253
Hardness	-0,203	-0.022
PAG	-0,103	0,156
Mg	-0,193	-0,082
NUMBER 3	-0,275	-0,080
NO2	-0,042	-0,357

Dissolved oxygen	0,168	-0,367
Total SUSPENDED Solids (TSS)	-0,003	-0,305
SO4	0.061	-0,041
Eigenvalues	0,740	0,679
Proportion explained	0,169	0,155

Variation of bofedal vegetation among sites

The most common species among the bofedal studied were *Agrostis foliata* Hook, Erigeron L. and *Lachemilla orbiculata* (Ruiz & Pav.). The species Distichia muscoides, Geranium diffusum Kunth, Lachemilla andina (LM Perry) Rothm and Vaccinium floribundum Kunth. were only present in the Lazabanda wetland.

The species Oritrophium peruvianum (Lam.) Cuatrec. and Plantago rigida Kunth. were unique to Casa Condor; Carex bonplandii Kunth. and Myriophyllum quitense Kunth. were only found in Pampa Salasacas; Bidens andicola Kunth. and Gnaphalium purpureum L. were only found in Portal Andino; Bartramia potosica Mont. and Gentianella cerastioides were only found in Puente Ayora ANI; Agostris brevivulmis (J. Presl) Hitchc and Azorella biloba (Schltdl.) Wedd. were only found in Puente Ayora AI; Ranunculus peruvianus Pers. was only found in Cruz Arenal ANI; Trifolium repens Walter was only found in Río Blanco.

The Non-Metric Multidimensional Scale (NMDS) analysis clearly differentiates the vegetation composition of the bofedales of the Pastaza and Chambo watersheds (with higher NMDS Axis 1 and Axis 2 scores) and the bofedales of the Llangana and Chimbo watersheds (B). In terms of intervention status, the "BI" bofedales presented higher NMDS Axis 1 than the "BNI" bofedales (D). The NMDS did not clearly differentiate vegetation composition and structure in terms of intervention status or threat level.

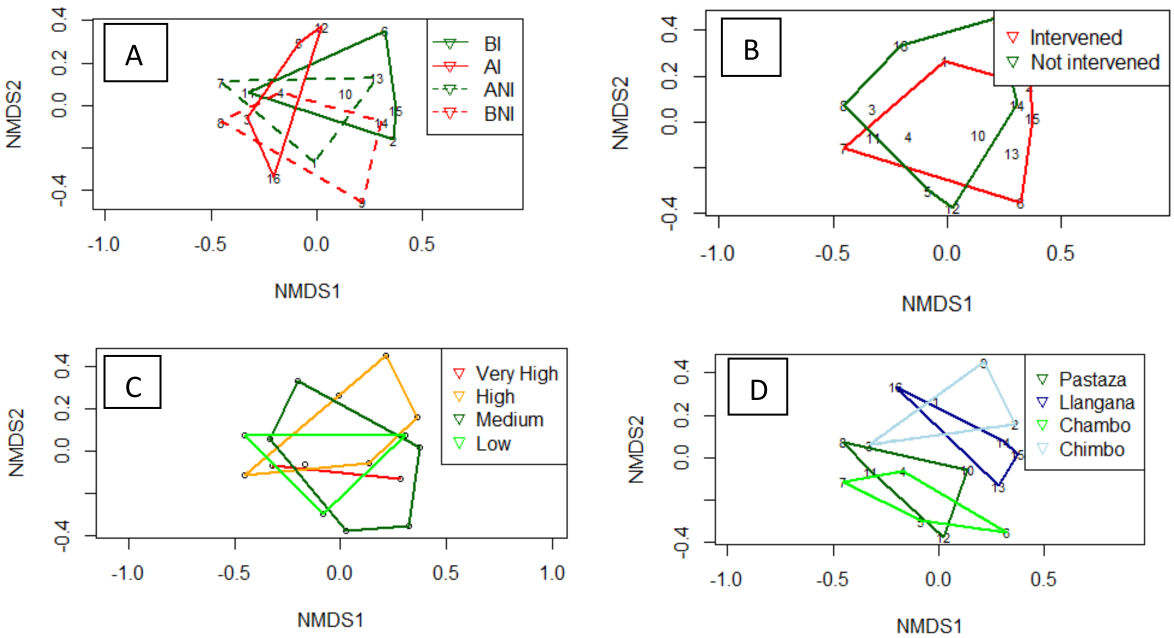

Figure 6. NMDS of bofedal vegetation where convex hulls represent groups based on a) intervention level; b) intervention status; c) threat level; d) watershed. NMDS stress = 0.087, R2 = 0.992.

1 - Pampa Salasacas, 2- Rio Blanco, 3- Mechahuasca, 4 - Cruz del Arenal BNI, 5 - Cruz del Arenal ANI, 6 - Culebrillas, 7 - Casa Condor, 8-Coop Santa Terersita, 9-Lazabanza, 10- Condor Samana, 11- Portal Andino, 12 - Los Hieleros, 13- Pachancho, 14 - Puente Ayora BNI, 15 - Puente Ayora AI, 16- Puente Ayora ANI

The multivariate analysis of variables related to water and soil quality, according to the HJ-Biplot methodology, shows that 63.55% of the variance can be explained with 4 axes. With axes 1 and 2 that explain 39% of the variance, it is observed that the Bofedal Casa Cóndor BI (W11) has a higher concentration of Ca, Mg, CEC. The Portal Andino AI (W10) and Culebrillas AI (W12) wetlands stand out for the presence of granulometry >0.1, Total Solid Suspension, OD(%), ODm, pH. Puente Ayora BNI (W3). Puente Ayora ANI (W2), Lazabanza (B8), Cruz del Arenal ANI (B4) differ by texture, NH_4 content and granulometry <0.1 (Figure 7).

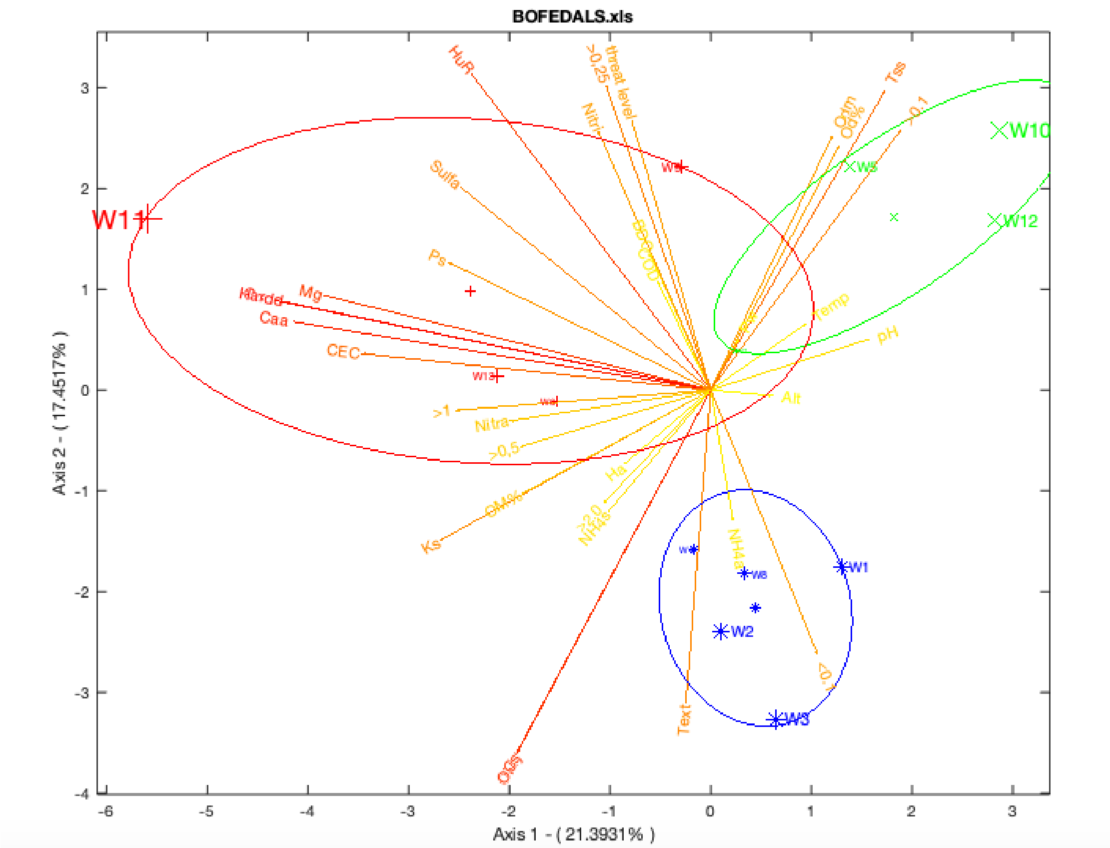

Figure 7. Biplot outcome of bofedals and physiochemical variables displayed in the 1 and 2 axes.

In the 1 and 3 axes that explain 35.47% of the variance, the Casa Cóndor BI (W11) is characterized by having high values in Ca, Mg, Hardness. The Bofedal Culebrillas AI (W12) and Portal Andino AI (W10) are distinguished by their particle size >0.1, oxygen, total solids in suspension, temperature, pH, altitude, particle size >0.1, particle size <0.1, Oxygen dissolved (Figure 8).

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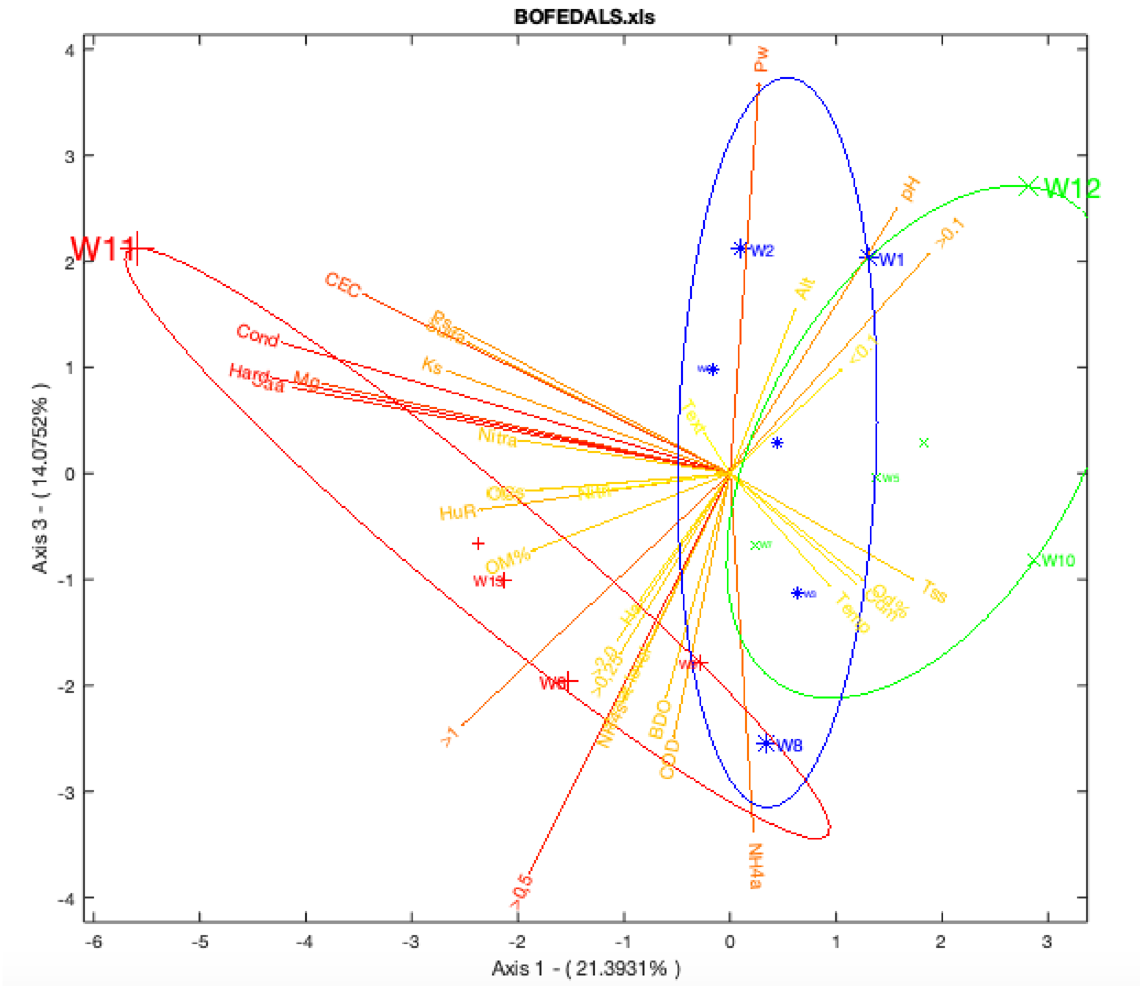

Figure 8. Biplot outcome of bofedals and physiochemical variables displayed in the 1 and 3 axes.

When it is analyzed axes 1 and 4 that explain 32% of the variance, Bofedal Casa Cóndor BI (W11) is distinguished from the other bofedales by having the highest values in the contents of Calcium, Magnesium, Phosphorus, Organic Matter, Nitrates, Nitrites, total solids in suspension, and the granulometric content >0.2, >1 , >0.5, which they share with the Bofedales Pampa Salasaca BI (W9), Cóndor Samana BI (W13) and Pampa Salasaca BI (W9) (Figure 9).

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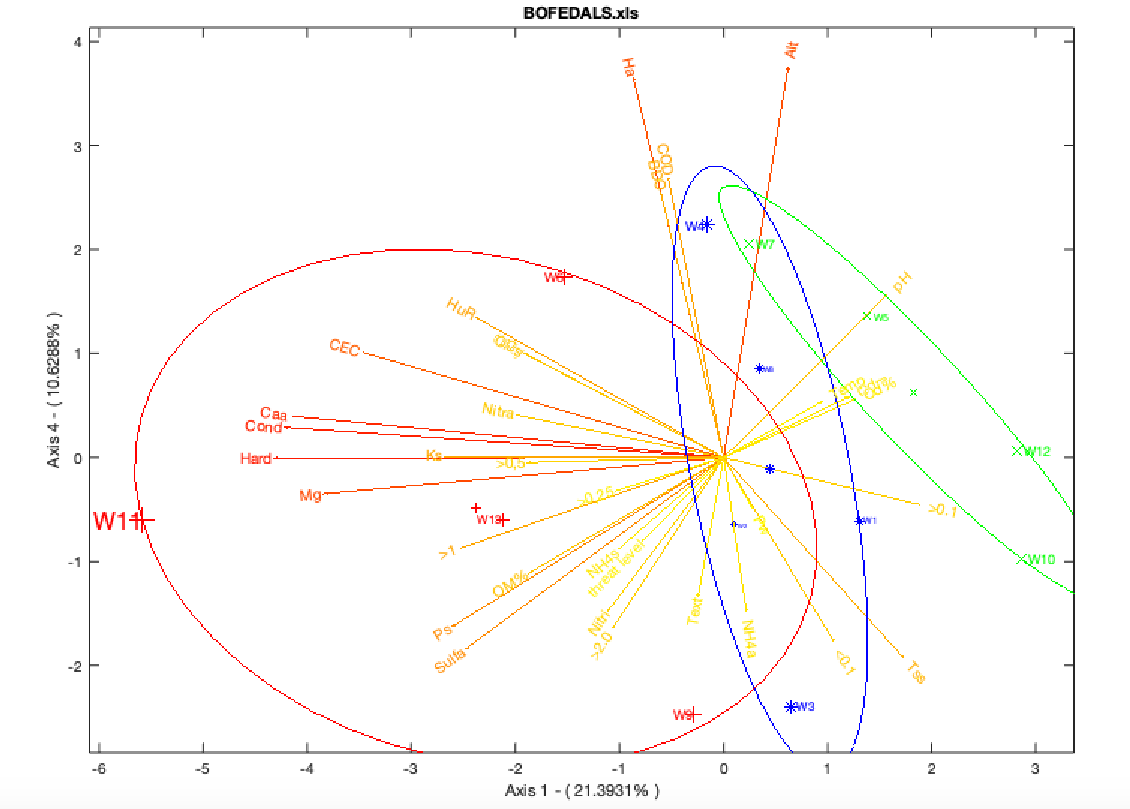

Figure 9. Biplot outcome of bofedals and physiochemical variables displayed in the 1 and 4 axes.

When considering axes 2 and 3 that explain 32% of the variance. The Bofedal Puente Ayora ANI (W2), Lazabanza BNI (W8), Puente Ayora BNI (W3), Cruz del Arenal ANI (W4), and Puente Ayora AI (W1) are the best represented, which have high values of K, dissolved oxygen, texture, and granulometry <0.1 (Figure 10).

Bofedal Culebrillas AI (W12), Portal Andino AI (W10) and Cruz del Arenal BNI (W5) are characterized by having high values of NH4, Calcium, Phosphorus, dissolved oxygen, and granulometry >0.25. The Bofedal Pampa Salasaca BI (W9), is distinguished by the chemical oxygen and biochemical oxygen demand and the water temperature (Figure 10).

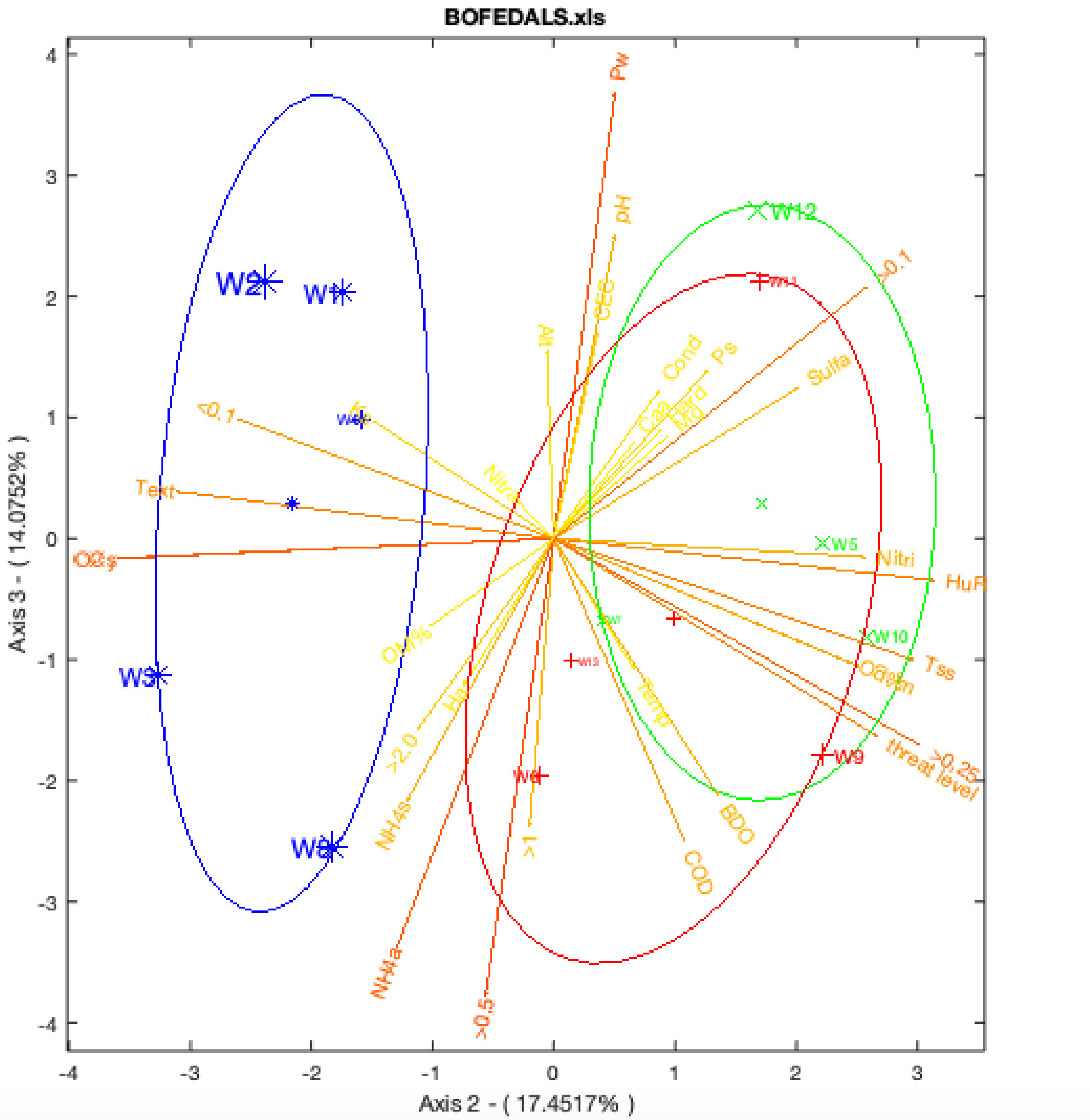

Figure 10. Biplot outcome of bofedals and physiochemical variables displayed in the 2 and 3 axes.

When considering axes 3 and 4, all bofedales share the physical-chemical characteristics analyzed in both water and soil. The Phosphorous content, sulfates, and particle size <0.1 are negatively corelated with oxygen and chemical demands and hectares, as the pH with NH_4 in water and soil. The Río Blanco AI (W6), and the Mechahuasca ANI (W7) are characterized by its extension in surface in hectares and the humidity regime (Figure 11).

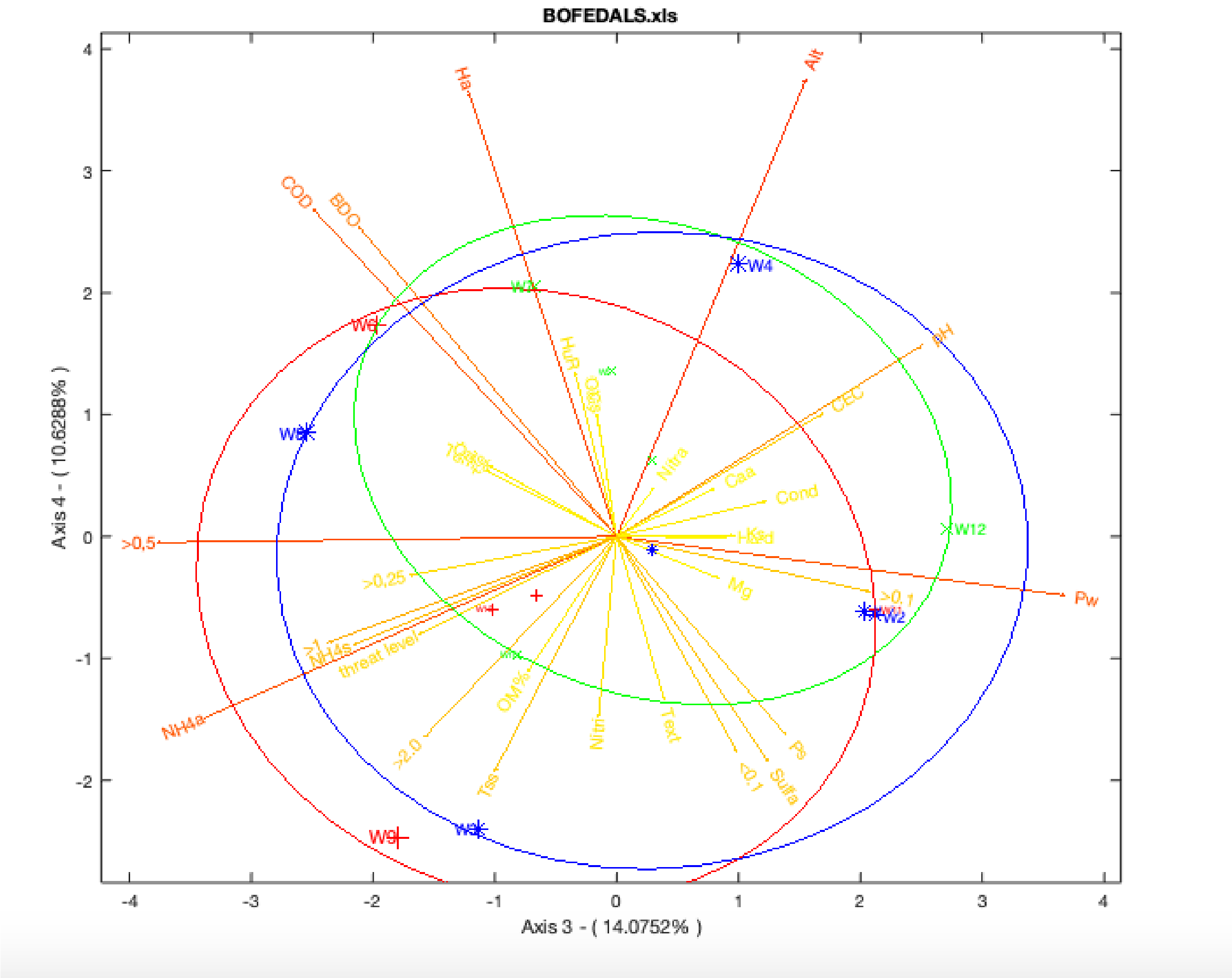

Figure 11. Biplot outcome of bofedals and physiochemical variables displayed in the 3 and 4 axes.

4. Discussion

In general, the 16 bofedales of the Chimborazo Fauna Production Reserve present a similar number of species, with a total of 79 sp. (62 vascular plants, 12 bryophytes, 4 ferns and 1 lichen), belonging to 64 genera and 35 families; a pattern typical of Andean paramos that are characterized by a floristic diversity richer in species than that of any other tropical-alpine ecosystem (Smith and Cleef 1988; Sklenář et al., 2011; Madriñán et al., 2013).
Bofedales are usually complexes of different plant communities whose composition and abundance are related to the amount and availability of water (Maldonado Fonkén, 2014). Vegetation is directly related to macroinvertebrate microenvironments (Passuni and Fonkén, 2015). Several authors have suggested that compositional changes in vegetation are mainly determined by the elevation gradient (Troll 1968; Baruch 1984).
In this study, we determine the relative contribution of variables driven by natural impact (Vásquez et al., 2015) and the effect of environmental filters (water and soil), considered as decisive factors in shaping plant diversity patterns and the ecology of these bofedales in general (Bragazza et al., 2005; Sottocornola et al., 2009; Hill et al., 2016; Nicia et al., 2018; Glina et al., 2019; Griffiths et al., 2019). As shown

by studies by Scheffer (1998), macrophyte cover and diversity contribute to the structural heterogeneity of the aquatic environment and thus may be guiding factors for system functioning (Jeppesen et al. 1997) and the abundance and diversity of higher trophic levels (Declerck et al.2005).

In this study, soil properties between habitats were markedly different. To find possible structure in the variability of the database, a principal component analysis (PCA) was performed. This analysis showed that the first three dimensions explained 69.6% of the variation in the data. Thus, demonstrating that, in the relative contribution of soil, CO and texture had the lowest loadings in PC1, while K and P had the highest loadings in PC2. The latter improves the efficiency of soil microbial decomposition (Zhang et al., 2017). Such a trend could be the result of higher plant biomass and high nutrient content (Fayiah et al., 2019). In their study Passuni and Fonkén (2015), determined that soil cover was a more useful indicator than diversity indices or plant community composition in terms of water requirements.

But this result contrasts with the findings of research conducted in cultivated soils and with the presence of afforestation. For example, Yang et al., Et al. 2021 showed that in cultivated land OC, TP, C / N and OP levels predominate; unlike the study of Yu et al., 2011, Fang et al., 2014).

A fundamental aspect of aquatic systems are the abiotic characteristics of the water, which are generally influenced by the nature of the substrate; however, some may have variations related to the increase of organic matter. In this study, in terms of water circulation, temperature did not vary significantly between wetlands, however, this parameter is closely related to dissolved oxygen and BOD; bacteria and microorganisms develop rapidly in warm water, at cold temperatures the concentration of dissolved oxygen is higher and the probability of survival of aquatic species is greater (CIECE, 2006).

Conductivity remained in the range 143.50-209 µS / cm, being the highest reported in the Casa Condor BI wetland; it corresponds to the hardness of water with high calcium content (Calvo et al., 1992). The concentrations of n-nitrates in the samples analyzed were less than 0.70 mg/L, suggesting that the contribution of discharges of this compound is minimal. Research carried out in Uruguay for surface waters report concentrations of less than 2 mg/L of n-nitrate, thus reporting that levels of less than 3 mg/L could be considered characteristic of natural waters (Perdomo et al., 2001; Melvin et al. al., 1992). Nitrate showed a tendency to be negatively correlated with aquatic plant cover and aquatic plant species richness. For example, a study by Coronel (2004) indicated that concentrations of this nutrient appeared to be determined by aquatic plants, rather than the nutrient limiting vegetation growth.

Dissolved oxygen is an indicator of organic matter contamination; low concentrations of this parameter can be located where organic matter is decomposing, meaning that bacteria that use oxygen to break down waste are also low in warm, slow-moving waters (Picone et al., 2003). Waters with dissolved oxygen concentrations above 4.1 mg / L are considered good quality, in the RPFCH wetlands DO concentrations remained above 6.11 mg / L (CIECE, 2006).

Practically for the PCA with water parameters in the wetlands, Ca presented the highest loads; while pH showed the lowest loads, perhaps because the main sources of hydrogen ions supplied to the wetlands are the result of rainfall runoff input, nitrogen immobilization, carbonic acid dissolution, organic acid dissociation and sulfur oxidation in low water conditions (McLaughlin and Webster, 2010; Nicia et al., 2018), as demonstrated in a study by Yabe et al., 2021, where pH values gradually decreased due to the above factors.

Both the chemical characteristics of the water and the aquatic plant communities present in the bofedales of the Chimborazo Fauna Production Reserve seem to respond to a mineralization gradient (as indicated by high values of electrical conductivity and dissolved ions). From a conservation point of view, the wetlands studied harbor an important percentage of the country's native plants. In addition, due to the geographic location of the wetlands of the RPFCH, these areas offer an ideal system for the study of meta-communities (dispersal-linked communities (Leibold et al., 2004).

5. Conclusions

Both the chemical characteristics of the water and the aquatic plant communities present in the bofedales of the Chimborazo Fauna Production Reserve seem to respond to a mineralization gradient (as indicated by high values of electrical conductivity and dissolved ions). The Phosphorous content, sulphates, and particle size <0.1 are negatively corelated with oxygen and chemical demands and hectares, as the pH with NH_4 in water and soil.

Bofedal Casa Cóndor is distinguished from the other bofedales by having the highest values in the contents of Calcium, Magnesium, Phosphorus, Organic Matter, Nitrates, Nitrites, total solids in suspension, and the granulometric content >0.2, >1, >0.5, which they share with the Bofedales Pampa Salasaca, Cóndor Samana BI and Pampa Salasaca BI

6. References

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Apéndix A

Table 5. Characterization of the bofedales

Bofedal	Province	Latitude	Longitude	Altitude (m.a.s.l.)	area total (ha)	Ecological clasification
Los Hieleros ANI	Chimborazo	745741	9833916	4442	25,67	Herbazal y arbustal siempre verde subnival del páramo
IA de Culebrillas	Chimborazo	735446	9831848	4160	13.31	Herbazal inundable del Páramo
Casa Cóndor BI	Chimborazo	739244	9831672	4008	9.40	Herbazal inundable del Páramo
Coop Santa Teresita BNI	Chimborazo	744365	9831911	4041	1,84	Herbazal y Arbustal siempreverde subnival del páramo
Lazabanza BNI	Tungurahua	746734	9850338	4039	26,46	Páramo subnival herbazal húmedo
Cóndor Samana BI	Tungurahua	751109	9839489	3825	21.36	Herbazal húmedo montano alto superior del Páramo
Pampas Salasacas BI	Tungurahua	754972	9845283	3854	154,40	Herbazal húmedo montano alto superior páramo
Río Blanco AI	Tungurahua	746179	9849003	4016	65,44	Arbustal siempreverde y Herbazal del Páramo
Mechahuasca ANI	Tungurahua	743954	9844037	4240	35,48	Herbazal del Páramo
Portal Andino AI	Chimborazo	750019	9837891	4120	7,62	Herbazal y arbustal siempre verde subnival del páramo y Herbazal del Páramo
Cruz del Arenal ANI	Bolívar	731162	9844778	4240	57,75	Herbazal y Arbustal siempreverde subnival del páramo
Puente Ayora ANI	Bolívar	728478	9841941	4105	12.19	Herbazal y arbustal siempre verde subnival del páramo
Puente Ayora BNI	Bolívar	726486	9839401	3842	0,29	Arbustal siempre verde y herbazal del páramo
Puente Ayora AI	Bolívar	728013	9841127	4120	12,84	Herbazal y arbustal siempre verde subnival del páramo
Pachancho BI	Bolívar	728315	9847854	4040	8,78	Herbazal y arbustal siempre verde subnival páramo
Cruz del Arenal BNI	Bolívar	732671	9840421	4120	18,78	Herbazal húmedo montano alto superior del Páramo