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FACTORS AFFECTING SPATIAL DISTRIBUTION OF *Typha* IN KANO-HADEJIA-NGURU WETLANDS

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ABSTRACT
Kano-Hadejia-Nguru wetlands provide conducive environment for the growth and development of Typha grass which has a devastating effect on agricultural activities in the area. An experimental investigation was conducted to determine the spatial distribution of Typha species and the factors affecting it. The study evaluates the nature of the relationship between Typha growth characteristics and soil/water parameters with a view of determining the major contributing factors to Typha infestation and distribution. Five infested communities were randomly selected each in Kano, Jigawa and Yobe State. In each community, Typha stand count as well as water and soil samples were taken for analysis from 4m² size quadrats in 2013 dry season (January to May). Principal Component Analysis (PCA) and simple correlation analysis were conducted on the data generated. The results revealed that Jigawa state (46.9%) had the highest percent infestation followed by Kano (30.9%) while Yobe state had the lowest (22%). Few communities recorded mean Typha density of >20standsm⁻². The highest infestation was observed in Kabak and Likori (36 and 34.5%, respectively). The principal component revealed that the first six components accounted for about 83% variability and gave Eigen value > 1 out of the 25 components and are therefore regarded as the major factors affecting Typha density and distribution in the study area.OM,S(mg/l),EC(us/cm),K(meq/100g),TDS (mg/l),B (mg/l),Cl(mg/l),SO₄(mg/l)NO₃- and N(mg/l)can be used to predict Typha occurrence and density in a particular environment.

Keywords: Typha, Distribution; Infestation; Hadejia Nguru wettlands

INTRODUCTION

Typha species (also known as perennial cattail) are a group of perennial, grass-like obnoxious invasive weeds, which have devastated most of the water ways and water bodies in many irrigation schemes and floodplains of northern Nigeria. It is an erect, rhizomatous, perennial aquatic weed which grows to 3 m tall with creeping rhizomes up to 70cm long (Larry,2000). It is an emergent saprophyte whose growth and development is affected by physical and chemical properties of both soil and water where it grows. *Typha* has dominated a major part of Kano-Hadejia-Nguru wetlands where it has been reported to cause hugelosses to farmers directly or indirectly (Lado*et al.*, 2016). The wetlands are rich in natural resources,having fertile soils and abundant water supply but the presence of *Typha*has been the major set back toward exploitation of these natural resources.

To provide scientific support to the implementation of the efficient*Typha* control measures that are cost-effective and environmentally friendly, knowledge of the spatial *Typha* distribution and the *Typha* biology are required. *Typha* species are more suited to shallow wetlands (Ralston*et al.*, 2007) while flooding depth of about 91-137cm have been reported to significantly decrease number of leaves, below ground and total *Typha* biomass (Chen *etal.*,2010).*Typha* shootswere also reported to be clumped at high water velocity whereas they were randomly distributed at low flow in stagnant water (Asaeda *etal.*, 2005). Water depth had significant effects on the growth and distribution of *Typha*. Water depth of about 68cm recorded high number of *Typha* shoot compared to shallow water depth (Sharma *etal.*,2008a).*Typha* may likely occur more frequently with high percent cover in wetlands around lakes with controlled water level.

High density of about 8.75 to 9.75 spp m^{-2} was reported in closed wetland compared to 6.75 to 8.5 spp m^{-2} in open embankments (Asaeda *etal*., 2005). Changes in great lakes water level have enhanced establishment and persistence*Typha* species. Its abundance has increased and has been positively correlated with reduced hydrologic variability (Lishawa*et al*., 2010). Low water level has been linked to new invasion of *Typha*in wetlands (Boes and Zedler, 2008).

The available evidence seems to suggest that chemical properties of soil and water may have profound effect on the growth and development of *Typha*.According to Lisa (2009),*Typha species* grow better with addition of N and P. It is a perennial rhizomatic plant that commonly grow in nutrient rich littoral habitat (Sharma *et al*.,2008) and elevated soil P concentration have been considered as a primary factor influencing its growth and distribution (Glenn *et al.,*1995). Different opinions were reported on the effect of salinity on *Typha* growth and development.Excess salt of about 7-10 ppm result in deteriorated*Typha* growth (Newman *etal*., 1998). However, Ralston *et al.* (2007) noted that frequent disturbance by tillage and elevated salinity condition contributes to the successes of hybrid cattail.

Because of its diverse morphological plasticity, it is important to understand how soil and water variables could affect*Typha* invasion and dominance in wetlands. This will assist in designing suitable controlmeasures that are cost effective and environmentally friendly. The living standard of the people around the infested area will be improvedas their life depends on free flow of water hindered by dense*Typha*population (Hussaini*et al*., 2012). Studies on *Typha* distribution and abundance are not only required inputsbut necessary tools for its successful control or management (Ralston *et al*.,2007).Combined effect of habitat manipulation and utilization may provide lasting solution to *Typha* problem but this can only be realistic only if factors affecting *Typha* habitat are well understood. There appears to be relatively little or no published information on the effect of *Typha* habitat manipulation on its control. To our knowledge, no field surveys have yet been conducted to determine the nature of *Typha* distribution and the factors responsible for it in the study area. The present study was designed with the following objectives; (i) To determine the prevalent location and spatial distribution of *Typha* infestation and (ii) To evaluate the nature of association between the environmental variables and *Typha*morphological characters iii) To identify variables that can be used to predict*Typha* density.

MATERIAL AND METHODS

Experimental Site and Sampling Procedure

Reconnaissance survey was conducted along Kano-Hadejia-Nguru wetlands to identify *Typha* infested communities in these areas. Random sample of five *Typha* infested communities were taken from each state. The details of the selected communities ispresented in Table 1.In each community, five quadrantsof 400 cm^2 were laid down at random thus 25quadrats were considered per state.Within each quadrant area, all *Typhaspp* were counted and recorded. Soil and water samples from each quadrate were collected for physic-chemical analysis while water depth was also taken by using meter rule.

For soil samples,the physical and chemical properties were determined in the laboratory using standard analytical methods. The soil pH was determined in soil-water ratio of 1:2:5 by using glass electrode pH meter (McLean, 1965) while total Nand available P were determined using the methods described byBremner (1965) and Bray and Krutz (1945), respectively. Exchangeable acidity was estimated using the $BaCl_2$-TEA method (IITA, 1979). Organic Cwas determined by wet oxidation method as described by Nelson and Sommers (1982). Exchangeable Ca, Mg, K and Na were extracted using the method described by Anderson and Ingram (1993). Potassium and Na were determined using flame photometer while Ca and Mg were determined using atomic absorption spectrophotometer. Electrical conductivity was determined using saturated paste extract of 1:2.5 soil water ratio using electrical conductivity meter at 25^oC (Bower and Wilcox, 1965). The CECwas estimated using the summation method (Chapman, 1965). Sulphur was determined using the turbid metric method (IITA, 1979). Boron (B) was determined by the colorimetric method. Bicarbonate (HCO_3^-) was determined by simple acidimetric titration in the presence of methyl orange at pH <6.0 (Baruah and Barthakur, 1998). Sulphate (SO_4^{-2}), nitrate (NO_3^-) and chloride (Cl^-) ions were determined using the procedure described by Chopra and Kanwar (1991). Organic carbon (OC) in the soil samples was estimated using thewet oxidation method as described by Nelson and Sommers (1982). Organic Matter (OM) was calculated by multiplying the corresponding values of OC with 1.8.

Data analysis

Principal component analysis

Principal component analysis was done using JMP 13th Edition.Pearson Correlation was carried out to determine the association between the soil and water properties with *Typha* density. Regression analysis was done to determine an accurate model to be used in predicting *Typha*occurrenceand the density. The sketch map of the sampling location is presented in figure one.

Table 1. Study Locations and their coordinates

Location	State	Latitude	Longitude
Garinbabba	Kano	11^{O}35.992'	8^{O}26.494'
ZangonBahari	Kano	11^{O}39.436'	8^{O}32.833'
Munture	Kano	11^{O}31.001'	8^{O}27.379'
Refawayamma	Kano	11^{O}32.338'	8^{O}27.289'
Refawagabas	Kano	11^{O}33.195'	8^{O}27.549'
Adiyanu	Jigawa	12^{O}48'31"	10^{O}25'56"
Gubusun	Jigawa	12^{O}38'09"	10^{O}19'29"
Kabak	Jigawa	12^{O}41'10"	10^{O}19'06"
Marma	Jigawa	12^{O}39.645'	10^{O}20.264'
Likori	Jigawa	12^{O}38.272'	10^{O}16.721'
Ngurulake	Yobe	12^{O}50.561'	10^{O}26.156'
DabarAlhajiGiwa	Yobe	12^{O}47.89'	10^{O}28.846'
Garbi	Yobe	12^{O}52.413'	10^{O}15.503'
SabonGarinMalam Ibrahim	Yobe	12^{O}49'52"	10^{O}18'02"
Saleri	Yobe	12^{O}50'01"	10^{O}19'36"

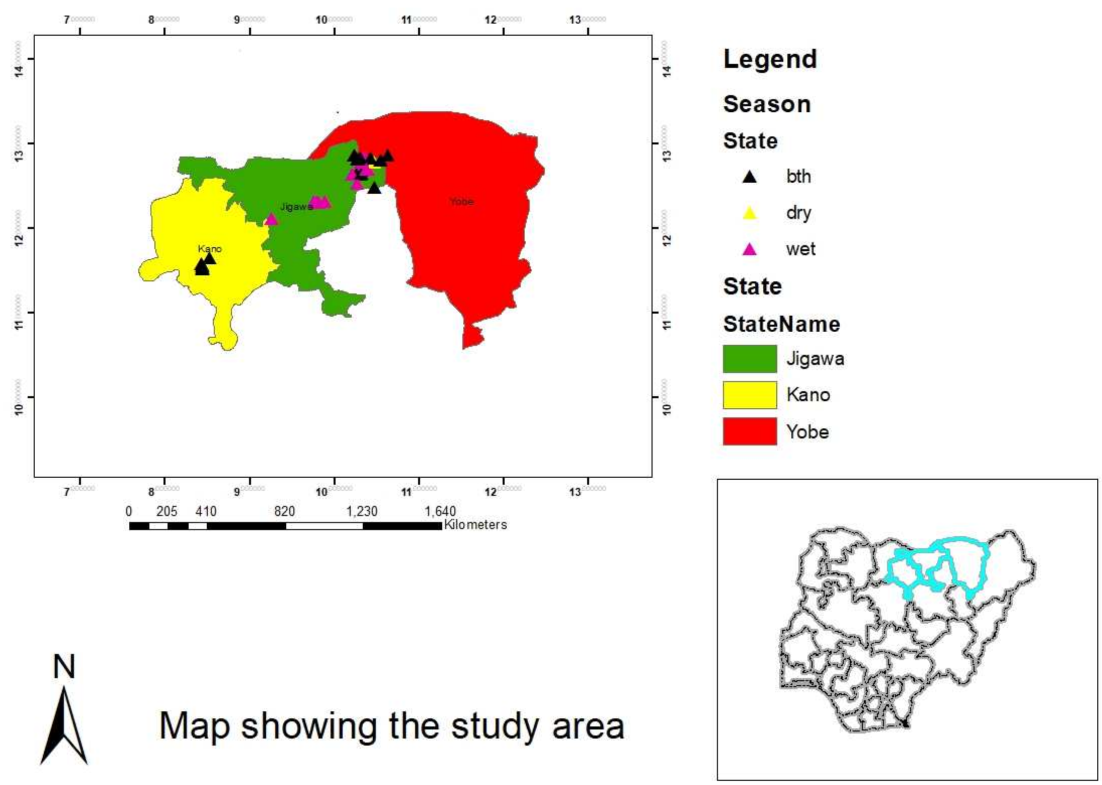

Figure 1: Map of the Study Location and Sampling Points

RESULTS

The percent *Typha* distribution across the three states is presented in Figure 2. The results indicated that 46.9% of the *Typha*sppwas found in Jigawa State while Kano and Yobe states had 30.9 and 22.2% respectively.*Typha* density varied among the study locations as indicated in Figure 3. Across the communities, the highest density was obtained from Kabak (34 m^{-2}). The lowest density was observed from Dabar A. Giwa, Sabongarin M. Ibrahim and Ngurulake with less than 20 *Typha*m^{-2} in the study location. The distribution of *Typha* among the three states was uneven,Jigawa had the highest density ranging from 22-34 *Typha*sppm^{-2}. The density ranges from 15-23 plants $m^{-2}$with amean of 17 m^{-2} in Kano state andthe lowest density was obtained from Yobe state where *Typha*density ranged from 12-16 with amean of 13 *Typha*m^{-2} (Figure3). *Typha*distribution in the study area where the study was conducted is presented in Figure 4. The mean *Typha* densitywas 18m^{-2}. From the scree plot, an elbow was observed at the 6^{th} PC and after which it tends to straight (Figure 6). The principal component reveal that the first six components accounted for about 83% of variability with Eigen values above 1 while the remaining 19 had Eigen values below 1. The 6 components were given due importance for further explanation and accounted for a greater variability among them (Table 2). The loading of the principal components are shown in Table 3. The first component was loaded with Na, Ca, Mg, TDS, EC, SO_4, NO_3 and HCO_3. The second component was loaded with OC, OM, S,P, Na, K,Ca, Mg and SO_4. The third component was loaded with, pH in water, P, K and B. Fourth component was loaded with S,Mg, SO_4 and NO_3; the fifth was loaded with N,Na and B while the sixth component was loaded withCa,B, Cl and No_3. The principal component biplot reveals the relationship among traits (Figure 7). The biplot shows that the variables are super imposed on the plots as vectors. Distance of each variable with respect to PC1 and PC2 shows the contribution of variable in the variation of *Typha* density.

From the correlation matrix in Table 4, only P was significant and positively correlated with *Typha* density. A positive significant correlation existed between P and depth of water while a negative significant correlation with pH in water and organic carbon. Five models for predicting *Typha*density were determined (Table 5), among which the 4^{th} model gave the highest r^2 (0.97) and lowest RMSE (2.18), AIC (127.14) and a low BIC of (79.22). The model indicates that OM,S(mg/l),EC(us/cm),K(meq/100g),TDS (mg/l),B (mg/l),Cl(mg/l),SO_4(mg/l)NO_3- and N(mg/l)canbe used to predict*Typha*occurrence and density in a particular environment.

DISCUSSIONS

The study revealed that Jigawa state had the highest *Typha* density. This resulted to higher number of Queleabird and displacement of many fishermen. The area was also known for disappearance of many palatable pasture grasses and this has affected herdsmen in a negative way.The allelopatic effect of *Typha* createdunconducive environment for many grass spp that are palatable to livestock, thus creating feed scarcity. Dense *Typha* population has been reported to alter micro site temporary and gradually exclude other aquaticmacrophytes resulting in reduced species richness and diversity in invadedwetland (Tuchman *et al*., 2009). The dense *Typha*population in the area creates a lot of environmental problems in the affected communities. Several hectares of irrigable land have been abandoned due to high population of the weed (Hussaini*et al*., 2012). Yobe state recorded low*Typha* density, probably due to seasonal fluctuation of water levels. There is blockage of water ways by *Typha* in the upper streams (Hadeja area of Jigawa state). This affected agricultural activities of the infested communitiesas farmers in the down streams (Saleriand Nguru lake area of Yobe state) have no enough water to irrigate their crops. This has created persistent conflict between water users of upper and lower streams because farmers producing down streams accuse farmers of the upper streams of deliberately blocking the water ways to create water scarcity in their farm lands.

Wide variation of*Typha* density was observed among the three states. Medium infestation was observed in Kano state and this could be attributed to the fact that the people of the area have found alternative uses of *Typha*which resulted frequent harvest thus reducing its density. Farmers around I Kanocut and use *Typha* in making basketswhich are used in transporting tomato to Southern part of Nigeria. This practice has helped greatly in reducing *Typha* density in the areawhen compared to Jigawa state where an alternative use of *Typha* is yet to be exploited. This means that *Typha* can be controlled by finding its alternative uses. This will create job opportunities and wealth. The dense *Typha* population in Jigawa state blocked water ways leading to Yobe states thus creating seasonal water shortage in the area. This might have been responsible for low *Typha*density in the state as the growth and development of this invasive weed depend on regular flow of water (Hussaini*et al*., 2012).

The study revealed that soil and water properties are important factors in determining Typha density and occurrence. To design suitable *Typha* control measures manipulation of both soil and water properties are essential. A combined effect of habitat manipulation and utilization was reported to provide lasting solution to aquatic weed control including *Typha*(Murphy,1988). Therefore biplot can be a valuable tool for direct and indirect manipulation of *Typha* habitat for its control.For prediction of *Typha* density, the regression model identified EC as the most critical factor in *Typha*predictions. Other components that can be used to support EC in prediction are OM, K, TDS, B, Cl, SO_4 and NO_3.

CONCLUSION

The percent Typha distribution across the three states indicated that Jigawa State may be more prone to the negative impacts of the weed in comparison to Kano and Yobe states. This may be attributed to the factors that were found to directly affect its distribution namely EC, OM, K,TDS, B and Cl all of which were favorable for the weed in the state.

Contribution of Authors: A. Lado and M. U. Dawaki are involve in conducting the research and writing of the Manuscript. Dr. G. Umour and S. A. Pantami participated in data taking and laboratory analysis while A. Shaibu and A. Adnan are responsible for the statistical analysis and its interpretations.

Conflict of Interest: None

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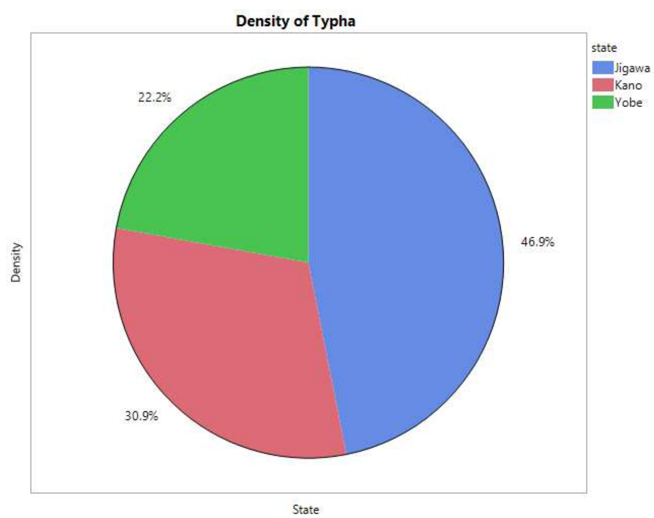

Figure 2: *Typha* stand count in various states

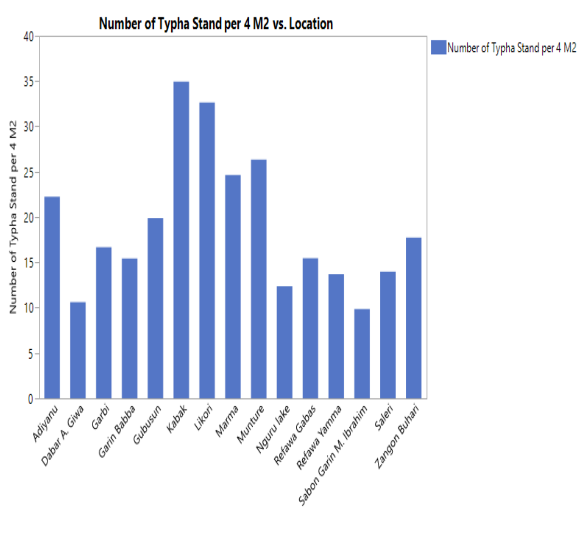

Figure 3. *Typha* Density in the various Loctaions

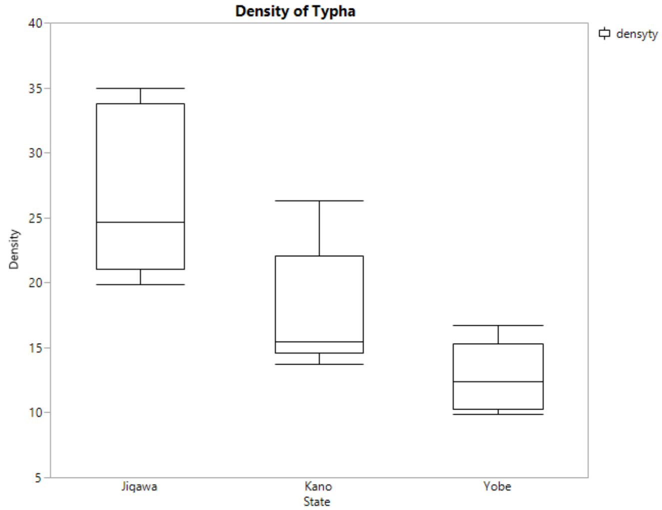

Figure 4: Boplox of mean Typha density per state

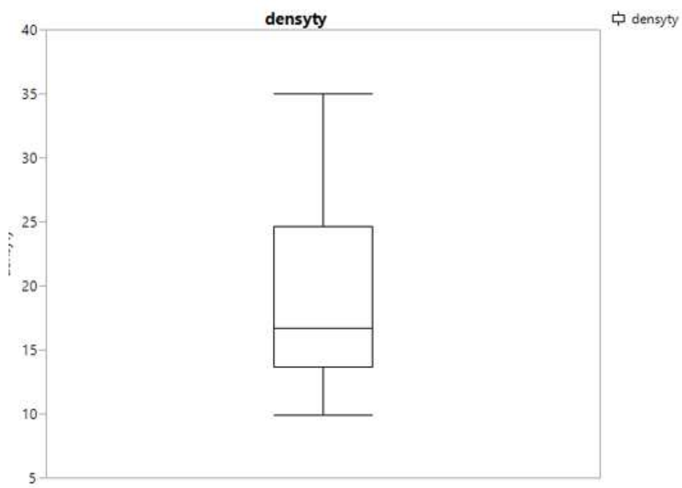

Figure 5: Boxplot ofTypha density in the Wetlands

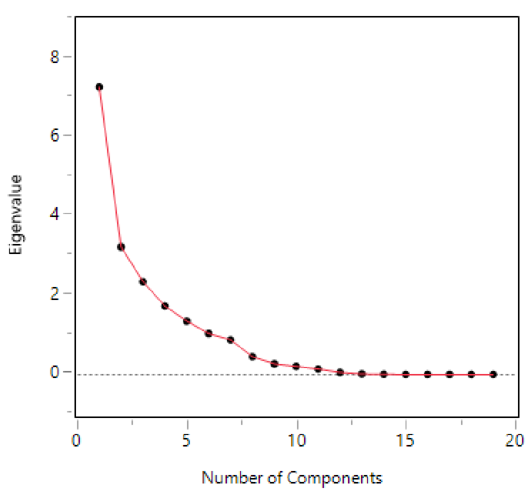

Figure 6. Scree plot for the principal components

Table 2. Eigen values for first 4 PCs and variance explained

Factor	Variance	Percent	Cumulative Percent
PC 1	4.16	21.89	21.89
PC 2	4.06	21.14	43.03
PC 3	2.47	12.99	56.02
PC 4	1.86	9.58	65.59
PC 5	1.81	9.49	75.09
PC 6	1.59	8.35	83.44

Table 3. Principal component (PCs) for *Typha*, soil and water characteristics

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
Ph in water	-0.155505	0.019298	-0.861203	-0.094270	0.014957	0.211542
OC	0.050537	0.901951	-0.209970	0.227187	0.010115	-0.074771
OM	0.063943	0.909514	-0.223386	0.223715	0.008254	-0.064757
N	-0.080291	-0.000402	-0.087897	0.022008	0.983381	0.025073
Depth	-0.083355	-0.276636	0.240389	-0.046847	-0.058312	0.103930
P(mg/l)	-0.157513	-0.343047	0.858831	-0.131557	-0.042260	0.014633
S(mg/l)	-0.179738	-0.821927	0.143388	0.343319	-0.033953	-0.183425
EC(us/cm)	-0.194926	-0.031797	-0.012841	-0.054744	0.031296	0.108627
Na(meq/100g)	-0.507903	-0.444999	-0.116040	-0.246546	0.518961	-0.145564
K(meq/100g)	-0.205886	-0.308951	0.802833	-0.060414	0.071797	0.099642
Ca(meq/100g)	0.460230	0.713745	-0.095039	0.225313	-0.168860	0.371395
Mg(meq/100g)	0.415912	0.672508	-0.129039	0.473859	-0.122865	0.276070
TDS (mg/l)	0.973282	0.115859	-0.043335	0.141271	-0.056408	-0.077774
EC(µs/cm)	0.974249	0.116447	-0.043068	0.134515	-0.056628	-0.074572
B (mg/l)	-0.073232	0.012494	0.334113	-0.090077	0.698975	-0.501717
Cl (mg/l)	-0.181232	0.134810	-0.031845	-0.042456	-0.088726	0.929331
SO_4(mg/l)	0.335645	0.400046	-0.028456	0.838476	-0.044199	0.089104
NO_3-(mg/l)	0.608914	0.021161	-0.056467	0.677352	-0.010878	-0.307299
HCO_3 (mg/l)	0.957182	0.210473	-0.062152	0.136544	-0.081958	-0.018854

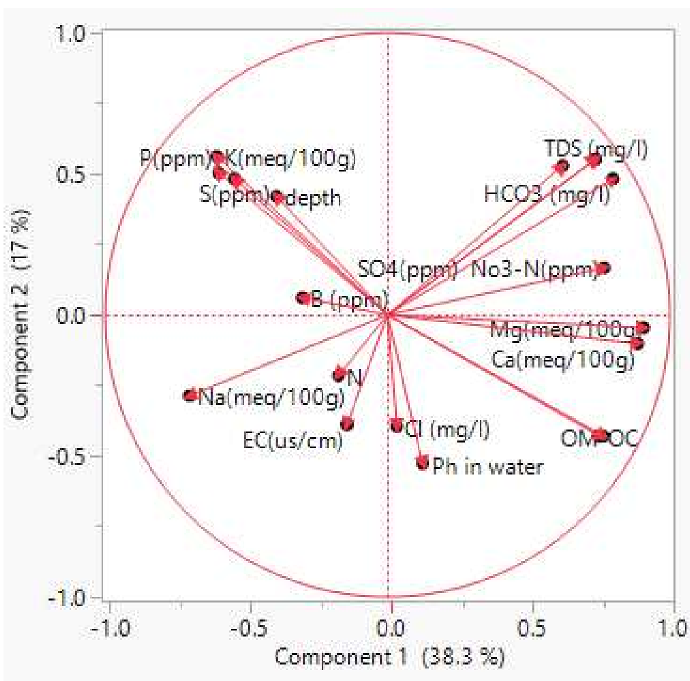

Figure 7.biplot of PC1 and PC2

Table 4. Correlation of properties of plant, soil and water

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Density	1.00																			
pH in water	0.05	1.00																		
OC	-0.06	0.16	1.00																	
OM	-0.17	-0.21	0.16	1.00																
N	0.09	0.13	0.02	-0.02	1.00															
Depth of water	-0.01	-0.05	-0.49	-0.11	-0.06	1.00														
P (mg/l)	0.47*	-0.58*	-0.56*	-0.08	-0.09	0.53*	1.00													
S (mg/l)	0.15	-0.09	-0.64**	0.32	0.01	0.27	0.46	1.00												
EC (us/cm)	-0.28	-0.24	-0.10	-0.14	0.03	-0.33	-0.15	-0.21	1.00											
Na (meq/100g)	-0.09	0.06	-0.26	-0.29	0.44	-0.04	-0.01	0.16	0.03	1.00										
K (meq/100g)	0.38	-0.51*	-0.52*	-0.15	0.05	0.61**	0.91**	0.44	-0.16	0.08	1.00									
Ca (meq/100g)	0.03	0.08	0.67**	0.10	-0.17	-0.23	-0.41	-0.52*	-0.08	-0.69**	-0.37	1.00								
Mg (meq/100g)	-0.01	0.08	0.69**	0.34	-0.12	-0.20	-0.43	-0.42	-0.14	-0.68**	-0.39	0.95**	1.00							
TDS (mg/l)	-0.16	-0.11	0.20	0.48	-0.12	-0.15	-0.22	-0.14	-0.26	-0.55*	-0.28	0.55*	0.54*	1.00						
EC (µs/cm)	-0.15	-0.11	0.20	0.48	-0.12	-0.15	-0.21	-0.15	-0.26	-0.55*	-0.28	0.56*	0.54*	1.00**	1.00					
B (mg/l)	-0.05	-0.33	0.02	0.19	0.46	-0.17	0.08	-0.06	0.14	0.26	0.03	-0.28	-0.18	-0.02	-0.03	1.00				
Cl (mg/l)	0.36	0.25	-0.03	-0.35	-0.04	0.12	0.07	-0.19	0.23	-0.32	0.04	0.36	0.27	-0.18	-0.18	-0.50*	1.00			
SO_4 (mg/l)	-0.10	-0.09	0.56*	0.74**	-0.04	-0.19	-0.31	-0.08	-0.14	-0.51*	-0.28	0.67**	0.84**	0.49	0.49	-0.08	0.05	1.00		
NO_3- (mg/l)	-0.15	-0.13	0.26	0.94**	-0.04	-0.17	-0.19	0.18	-0.25	-0.39	-0.25	0.29	0.47	0.73**	0.72**	0.12	-0.33	0.75**	1.00	
HCO_3 (mg/l)	-0.15	-0.08	0.28	0.44	-0.13	-0.17	-0.26	-0.22	-0.25	-0.60*	-0.31	0.65**	0.63**	0.99**	0.99**	-0.08	-0.11	0.53*	0.69**	1.00

** and * = significant at 1% and 5% level of probability, respectively

1 = Density, 2 = pH in water, 3 = OC, 4 = OM, 5 = N, 6 = Depth of water, 7 = P (mg/l), 8 = S (mg/l), 9 =EC (us/cm), 10 = Na (meq/100g), 11 = K (meq/100g), 12 = Ca (meq/100g), 13 = Mg (meq/100g), 14 = TDS (mg/l), 15 = EC (µs/cm), 16 = B (mg/l), 17 = Cl (mg/l), 18 = SO_4 (mg/l),19 = NO_3-(mg/l), 20 = HCO_3 (mg/l)

Table 5. Summary of 5 best regression model

Model	R-Square	RMSE	AICc	BIC
pH in water,depth,EC(us/cm),B (mg/l),Cl (mg/l)	0.8184	4.0707	107.020	95.9766
OC,S(ppm),EC(us/cm),K(meq/100g),B (ppm),Cl(mg/l),SO_4(ppm),NO_3-N(ppm)	0.9363	2.7341	115.310	85.6821
OM,S(mg/l),EC(us/cm),K(meq/100g),TDS (mg/l),B (mg/l),Cl (mg/l),SO_4(ppm), NO_3-(mg/l)	0.9654	2.1754	127.140	79.2209
OM,S(ppm),EC(us/cm),K(meq/100g),EC(µs/cm),B (ppm), Cl (mg/l), SO_4 (ppm), NO_3-(ppm)	0.9654	2.1760	127.149	79.2290
OM,S(ppm),EC(us/cm),K(meq/100g),B (ppm),Cl (mg/l),SO_4(ppm), NO_3-(ppm),HCO_3 (mg/l)	0.9633	2.2425	128.051	80.1316