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The Possible Effects of Some Mineral Nutrients and Industrial Chemical Effuents on Wild Plants in Central Sudan
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الآثار المحتملة لبعض عوامل التغذية المعدنية و مخلفات الصناعة الكيميائية على النباتات البرية بوسط السودان

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تناولت هذه الدراسة أثر بعض المعادن المغذية و المخلفات الكيميائية الناتجة من مصنع نسيج و مدبغة على نمو نباتات : التايفا (*Typha angustata*) ، السعدة (*Cyperus laevigatus*) ، الباسبيليوم (*Paspalum viginatum*) ، السنامكة (*Cassia senna*) و اللصيق (*Xanthium brasilicum*) بالمنطقة الصناعية في الباقير بوسط السودان. اختيرت ثلاث مواقع في المنطقة الصناعية في الباقير لإجراء هذه الدراسة و هي : موقع النسيج "Textile site" و هو الموقع الرئيسي في هذه الدراسة ، و هو متأثر بالمخلفات الكيميائية الناتجة من مصنع للنسيج بالمنطقة؛ و موقع المدبغة "Tannery site" و فيه يُتخلص من المخلفات الكيميائية الناتجة من عملية دباغة الجلود ؛ و أخيرا الموقع الطبيعي "Natural site" الذي يمتاز بعدم تأثره بمخلفات الصناعة. يتسم موقع النسيج بنمو جيد للنباتات؛ و يمتاز موقع المدبغة بخلوه تماما من النباتات و لقد اختير لمعرفة الأسباب المسئولة عن عدم نمو النباتات به؛ أما الموقع الطبيعي ففيه تنمو النباتات بصورة طبيعية و قد اختير لأغراض المقارنة.

أوضحت نتائج التحليل الكيميائي للتربة تباينا واضحا في محتوى التربة من العناصر المعدنية بالمواقع الثلاثة. كما أظهرت النباتات بموقع النسيج معدلات امتصاص عالية لأيون الصوديوم (Na^+) مصحوبة بمعدلات امتصاص منخفضة لأيون البوتاسيوم (K^+). و هذه السمة التي توحي بالخصائص التي تمتاز بها النباتات الملحية يمكن تفسيرها على أساس أنها آلية تنظيمية تقوم بها النباتات لتفادي الآثار السامة و التأثيرات الأزموزية التي يمكن أن تنشأ من التركيزات العالية لأيون الصوديوم بهذا الموقع. من جانب آخر فإن معدلات الامتصاص العالية لأيون البوتاسيوم (K^+) بالنسبة لنباتات الموقع الطبيعي الذي يمتاز بمستويات منخفضة من البوتاسيوم عند مقارنته بموقع النسيج ، تشير إلى أن ازدياد تركيز أيون البوتاسيوم بمحلول التربة بالموقع الطبيعي له علاقة بالمستويات العالية لأيون الكالسيوم بنفس الموقع.

أظهرت النباتات موضع الدراسة تباينا واضحا في معدلات امتصاص الأيونات من محلول التربة بموقع النسيج و الموقع الطبيعي. كما أن المستويات العالية لتركيز النيتروجين (NH_4-N) و الفوسفور (P) بموقع النسيج كان لها دور

واضح في النمو الجيد للنباتات بهذا الموقع؛ و لقد ظهر ذلك جليا بالنسبة لنبات الباسبيليوم (*P. viginatum*) الذي امتاز بنمو جيد في موقع النسيج مقارنة مع الموقع الطبيعي. هذا، و لقد أشارت الدراسة إلى أن خلو موقع المدبغة من النباتات يمكن أن يعزى بصورة أساسية إلى احتوائه على مستويات عالية من الصوديوم (Na) و الكروم (Cr).

و أخيرا يبدو أن توزيع النباتات بموقع النسيج و الموقع الطبيعي ذو علاقة بتوزيع الموارد المائية و الغذائية و بالتباين في عوامل البيئة الطبيعية, كما يبدو أن هذه العوامل تمثل الأساس لتعايش النباتات بهذين الموقعين.

Key words: *Mineral nutrients, Industrial chemical effluents, Plant growth and distribution, Typha angustata, Cyperus laevigatus, Paspalum viginatum, Cassia senna and Xanthium brasilicum.*

ABSTRACT

The effects of some mineral nutrients and industrial chemical effluents from a textile factory and tanning activities on the growth and distribution of *Typha angustata, Cyperus laevigatus, Paspalum viginatum, Cassia senna* and *Xanthium brasilicum* at Al-Bagair Industrial Area, in central Sudan, were investigated. Three sites were selected for this study namely: the "Textile site", the main site in this study, represented by the area affected by disposals of chemical effluents from a textile factory; the "Tannery site" represented by the area covered by chemical pollutants from tanning activities; and the "Natural site" represented by an area located outside the industry polluted areas. The Textile site was characterized by good plant growth; the Tannery site, on the other hand, was characterized by complete absence of plant species, and it was included in this study to examine the factors responsible for inhibition of plant growth. The Natural site on which plants are growing naturally was selected for comparison purposes.

The soil chemical analysis data showed considerable variation between the investigated sites. The plant species in the Textile site showed high levels of Na uptake accompanied by a considerable K decline. This halophytic feature happened as a regulatory mechanism by the plants in the Textile site which contains high levels of Na to avoid the toxic and osmotic effects caused by high Na concentrations. On the other hand, the high levels of K uptake by the investigated species in the Natural site, which contains low levels of soil K when compared with the Textile site, suggested that K availability in the Natural site was improved by the high levels of soil Ca in the same site.

The investigated species showed different levels of mineral nutrient uptake. It was also shown that the high levels of NH_4-N and P in the Textile site were reflected visually in the good performance of plant species; and this was very clearly manifested by *P. viginatum* which showed greatly better performance in the Textile site than in the Natural site. Moreover, it was suggested that the high levels of Na and Cr seem to be responsible for inhibition of plant growth in the Tannery site.

Finally, the distribution of the investigated species in the Textile and Natural sites seem to be related with resources distribution and local environmental heterogeneity, and these most likely provide the basis of the coexistence of species in these two sites.

Introduction

The effects of mineral nutrients availability on plant growth and distribution have been widely investigated [1, 2, 3]. Actually, much of the variation commonly seen in natural vegetation of the semi-arid climatic zone of in central Sudan can be related to variation in soil moisture, and availability and cycling of mineral nutrients [4, 5].

The disposal of chemical industrial wastes, which often contains high levels of minerals and heavy metals ions, on natural soils alters the natural environment and may change the levels of the soil mineral ion concentrations [6]. In other words, the industrial chemical pollutants alter soil chemistry and set new conditions for plant growth and distribution. For instance, it was found that chemical disposals containing arsenic, copper and chromium, from a woody treatment factory, had greatly affected plant composition and abundance [7]. Moreover the effect of industrial compost on soil fertility was found to alter the levels of the available ions in the soil and to increase zinc content to levels that could cause toxicity problems for plants [8].

The industrial effluents from some manufacturing activities in Sudan have been analyzed. For instance, the effluents of Cotton Textile Mills and a Tannery at Al-Bagair Industrial Area were analyzed for the chemical oxygen demand (COD), biological oxygen demand (BOD), phosphorus, chromium, sulphide ions and pH, and it was concluded that the investigated parameters levels exceed those suggested by industrial regulations [9,10].

Although the industrial chemical effluents from manufacturing activities in Sudan have been analyzed by many investigators, no attempt had been made to evaluate the effects of chemical effluents on soil and vegetation. In this investigation the effects of mineral nutrient factors and industrial chemical effluents from a textile factory and tanning activities on the growth and distribution of *Typha angustata, Cyperus laevigatus, Paspalum viginatum, Cassia senna* and *Xanthium brasilicum* at Al-Bagair Industrial Area, in central Sudan, were investigated. It is hoped that this investigation will contribute to a better understanding of the ecology of the investigated species.

Materials And Methods

Description of the study area:

The study area, at Al-Bagair in central Sudan, is about 35 km. south east Khartoum (Figure 1). The climatic regime at Al-Bagair is typically to that of the southern fringes of the African tropical semi-desert. Rainfall is low with the mean annual of 150 mm. The brief rainy season, which usually occurs in the summer season (June-September), consists mainly of erratic showers and few rainstorms. Air temperatures were characterized by large daily and annual ranges. The mean maximum temperature ranges between 31°C in December and January and 42°C in April and May. Relative humidity is generally low, reached a maximum of 50% in August and a minimum of 18% during March, April and May.

Al-Bagair area represents the northern part of the Gezira clay plain. It is part of the Nubian Sandstone formation [11] which is covered with alluvial deposits called "Gezira clay" that consists of clay, sand and gravel. It has been concluded that the Gezira soil formation was polygenetic, i.e., the clays were brought about by the rivers flowing from the Ethiopian volcanic plateau and the coarse fraction was probably derived from the erosion of the Nubian sandstone formation and basement complex [12].

As mentioned above, the study area is located in the semi-arid region of the Sudan, and it has been described as part of the "*Acassia* Desert Scrub" characterized by some woody species like: *Acassia ehrebergiana, Acassia tortiles, Acassia spirocarpa* and *Acassia seyal*; one perennial, *Panicum turgidum* and few annuals like: *Aristida spp. Schoenfeldia gracilis, Eragrostis pilosa* and *Cassia senna* [13].

Three sites of contrasting soil nutrients and vegetation cover, within the study area were selected for this study. These sites were: The "Textile Site", the main site in this study,

affected by disposals of chemical effluents from a textile factory and characterized by the following plant species: *Cyperus laevigatus, Typha angustata* and *Paspalum viginatum*; the "Tannery Site" highly polluted with chromium and sodium salts of tanning processes and was characterized by complete absence of plant species, and it was included in this study to examine the factors responsible for inhibition of plant growth; and the "Natural site" characterized by natural growth of plants and was chosen in this study for comparison purposes. During this investigation for instance, which was characterized by widely interspread light showers during the rainy season, few annuals grew in the natural site. These annuals include: *Boerhaevia repens, Tribulus terrestris, Portulaca quadrifica, Paspalum viginatum, Cassia senna, Xanthium bracilicum* and *Calotropis procera.* The Natural site also include some woody species like: *Prosopis chilensis* and *Acacia nilotica.* All the above mentioned species were identified [14, 15].

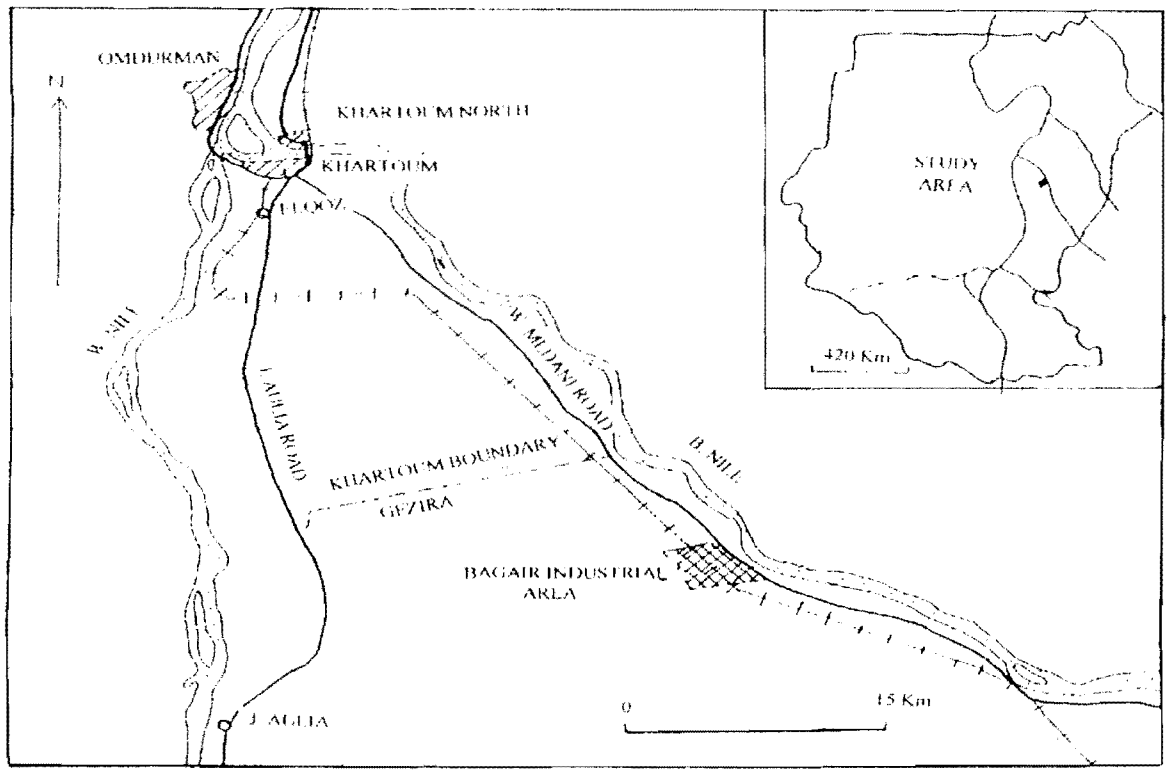

Figure 1: Location map of the study area at Al-Bagair in central Sudan.

Distribution and habitats of the investigated species:

The five investigated species, chosen for this study: *Typha angustata, Cyperus laevigatus, Paspalum viginatum, Cassia senna and Xanthium brasilicum* differ in their distribution and tolerance to environmental factors. No detailed work have been done on the distribution of these species, and so little is known about their ecological behavior.

Typha angustata, an aquatic herb, with a creeping rhizome, often tall; leaves alternate, simple linear rather thick or spongy. This species was found to be distributed in the regions of Khartoum greenbelt [16], and it was described as a semi-aquatic weed, in polluted water [17].

During the present investigation *Typha angustata* showed a successful growth in the Textile Site.

Cyperus laevigatus is a herb usually found in damp or marshy habitats. It was reported that this species is found in Red Sea district, Darfur and Eguatoria [15]. *C. laevigatus* is almost found in the Nile banks and local gardens; and it is able to thrive either by seeds or vegetatively by corms [15].

Paspalum viginatum, is a rare herb with strong creeping rhizome. It was found in the Imatong mountains in southern Sudan [15]. *P. viginatum* is distributed in the Natural Site with annuals and perennials and also shows highly successful growth in the Textile site.

Cassia senna is a glabrous undershrub with pale more or less zigzag branchlets. *C. senna* is a wide spread species in desert and semi-desert on sand and clays and in short grass savanna throughout north, south and central Sudan [18]. It was reported that *C. senna* occurs on all types of soils with best yield on clay soils [19]. *C. senna* was found growing in Khartoum greenbelt within and out the sewage irrigated sites [20], and it seems to have wide range of moisture tolerance [4].

Xanthium brasilicum is a coarse scabrous hairy or nearly glabrous herbs mainly distributed in central Sudan. *X. brasilicum* is almost distributed in the Nile banks [15].

It is also found in the private farms in Khartoum greenbelt [16]. These farms were characterized by a regular sufficient water supply and optimum soil conditions. Within Khartoum Province *X. brasilicum is* confined to the riverbanks and the mouth parks of principal wadies pouring into the rivers; in other words it was confined to habitats characterized by high moisture content [4].

Chemical analysis of soil and plant samples:

Soil and plant samples of the Textile Site, the main site in this study at Al-Bagair Industrial Area, were collected from 35 sampling points of 80x120m rectangular grid, each point is 20 meters distant from the other neighboring points. Ten random soil samples were collected from the tannery site; and 15 soil and plant samples were collected randomly from the Natural Site. The samples were taken from the plough depth (15-20 cm), because the plough layer is thought to be the most useful part of the soil and will best represent its ability to supply nutrients. The samples were placed in plastic bags and stored in the laboratory at temperature of about 25°C.

To estimate the mineral nutrient uptake of the investigated plant species, the newly formed leaves of each plant were collected from the sampling points of the three sites. The samples were dried at 45°C. for several hours in an oven, and ground to produce sufficiently homogenous materials for representative quantities to be taken for analysis.

Cations, Ammonium nitrogen and phosphorus (expressed in mg 100 g^{-1} soil), were extracted from a measured volume of soil (5 grams from each sample). Cations were extracted with ammonium acetate at pH = 7; Ammonium nitrogen was extracted with 6% sodium chloride; and extractable phosphorus with 2.5% acetic acid [21, 22].

Samples of an oven-dry plant material were digested with a sulphuric acid-hydrogen peroxide mixture, using selenium as a catalyst [21], in a digestion block apparatus. After digestion, the cold digest was diluted slightly and boiled to redissolve any precipitated ferric sulphate, filtered, and made up to volume with deionized water.

Analytical procedures, in general, are described elsewhere [21, 22]. K and Na were estimated by flame emissions, and other metallic cations by atomic absorption spectrophotometer. Ammonium-nitrogen was estimated colorimetrically using the Nessler reaction method. Phosphorus was analyzed colorimetrically by the molybdenum blue method using the spectrophotometer.

pH and Ash%:

The pH of the collected soil samples was determined on a 1:2 suspension of a soil sample in deionized water, using a glass electrode; whereas the ash percentage of the soil samples was determined by heating oven dried soil samples in a muffle furnace at 550°C.

Results

Soil chemical analysis data showed substantial differences in the concentrations of extractable ions between the three investigated sites (Table 1). The pH of the textile site is relatively higher compared to the other two sites. The two industrial sites are characterized by high levels of N, P, K, Na and Mn; and low levels of Ca and Mg compared to the natural site.

Fe levels are more or less similar at the three investigated sites. The tannery site, on the other hand, was characterized by high levels of Cr compared to the other two sites.

Of the five investigated species *Typha angustata and Cyperus laevigatus* were restricted to the textile site; whereas *Cassia senna and Xanthium brasilicum* were restricted to the Natural site. *Paspalum viginatum*, however, was present on both sites. *C. laevigatus* was found at 23 sampling points of 80x120m rectangular grid, which contains 35 sampling points at the Textile site, the main site in this study, at Al-Bagair Industrial Area; whereas, *P. viginatum* was found associated with *C. laevigatus* at 8 sampling points only. Actually *P. viginatum and C. laevigatus* were found at the periphery of the experimental grid characterized by moderate moisture content and relatively high levels of pH, Ca, NH_4-N and P; and they avoided the central part of the experimental grid characterized by high moisture content and relatively low levels of pH, Ca, NH_4-N and P. The central part of the Textile site was mainly covered by *T. angustata,* which was found at 10 sampling points.

P. viginatum was also found at 7 sampling points in the Natural site, mainly in depressions characterized by being moist and relatively rich in mineral nutrient content. *C. laevigatus,* however, was not present in the Natural site. It seems that *P. viginatum* prefers moderately moist habitats and it demands low mineral nutrients requirements compared with *C. laevigatus.* On the other hand, *X. brasilicum* and *C. senna* were restricted to the Natural site and they were almost found associated with each other. They were adapted to low moisture conditions compared to the other investigated species.

The chemical analysis data of the investigated plant species collected from the textile site and natural site is summarized in Table 2. Taken as a whole the results of the chemical analysis of the plant material were broadly within the expected range of the elements reported in the literature [21,23]. The data of the chemical analysis of the plant materials examined in each site showed only limited variation of chemical composition in relation to differences in the extractable elements in the soil. From one point of view, this was not surprising, because plants regulate their uptake of essential elements [24]. It was concluded that tissue nutrient concentrations of wild plants are less sensitive indicators of soil nutrient availability [25]. On the other hand Table 2 showed substantial differences in the uptake of mineral ions between

the investigated species. *T. angustata*, *C. laevigatus*, and *P. viginatum* grown on the textile site have higher concentrations of P, Na, Mn, and Mg, and lower concentrations of K, and Ca, when compared with *P. viginatum*, *C. senna* and *X. brasilicum* grown in the Natural site. This might reflect the high mineral nutrient status of the Textile site compared to the Natural site. In addition to that, the substantial differences in the average element composition between the investigated plant species may be due to the fact that the different plant species have different requirements for the essential elements.

Discussion

The soil chemical analysis data showed considerable variation between the investigated sites at Al-Bagair Industrial Area. It was clear that the industrial chemical effluents from the Textile factory and tanning activities altered the soil chemistry, and this was reflected in the variability in their mineral contents. For instance, the high levels of Na in the two industrial sites due to the high quantities of Na compounds used in the textile and tanning activities (NaOH, Na_2CO_3, Na_2SiO_3 and $NaHCO_3$ used in the textile processes, and $Na_2Cr_2O_7$, $Na_2B_4O_7.H_2O$, $NaHSO_4$, Na_2CO_3 and $NaHCO_3$ used in the tanning processes), greatly affected the soil chemistry of the two industrial sites and raised their Na ions to high levels, which could have great impact on the uptake of Na and K ions by the investigated plant species in the Textile site, which showed high levels of sodium uptake accompanied by a considerable potassium decline. This halophytic feature happened as a regulatory mechanism [26,27] by the plants in the Textile site to avoid the toxic and osmotic effects caused by high Na concentrations.

Table 1: Summary of the soil chemical analysis data : pH and extractable ions expressed in mg / 100 g soil of the three investigated sites.
Figures are means ± S.D.

Site	Textile	Natural	Tannery
No of samples	35	15	10
pH	8.32 ± 0.78	7.02 ± 0.30	6.94 ± 0.79
Ash %	26.68 ± 10.03	1.06 ± 0.30	1.02 ± 0.45
Ca	193.58 ± 46.45	468.28 ± 102.37	246.69 ± 54.69
Mg	60.83 ± 20.0	70.03 ± 32.06	48.87 ± 13.84
K	63.44 ±15.13	38.46 ± 7.69	160.00 ±19.55
Na	280.58 ± 118.72	169.30 ± 41.45	384.00 ± 58.72
Mn	0.52 ± 0.20	0.12 ± 0.05	0.35 ± 0.13
Fe	17.96 ± 2.53	17.45 ± 0.74	17.50 ± 0.43
NH_4-N	5.86 ± 1.25	3.53 ± 0.37	5.33 ± 0.81
P	4.75 ± 1.31	3.56 ± 0.68	5.20 ± 0.57
Cr	0.07 ± 0.03	0.06 ± 0.02	0.61 ± 0.25

Table 2: Chemical analysis of plant material from two sites in the investigated area at Al-Bagair.The figures given are mean ± S.D. Expressed as percentage dry-weight of plant material.

Site	Textile			Natural		
Species	*Typha angustata*	*Cyperus laevigatu*	*Paspalum viginatum*	*Paspalum viginatum*	*Cassia senna*	*Xanthium brasilicum*
No of samples	10	23	10	7	8	6
Mg	0.819 ± 0.251	0.743 ± 0.222	0.817 ± 0.227	0.454 ± 0.139	0.606 ± 0.167	0.638 ± 0.185
Ca	2.004 ± 0.657	2.148 ±0.608	1.565 ± 0.488	1.970 ± 0.607	3.540 ± 1.201	4.098 ± 1.383
K	0.939 ± 0.199	0.987 ± 0.366	0.951 ± 0.178	2.617 ± 0.903	2.820 ± 1.006	3.472 ± 0.705
Na	2.361 ± 0.366	2.626 ± 0.630	2.630 ± 0.272	1.466 ± 0.124	1.372 ± 0.218	1.518 ± 0.4 30
Mn	0.029 ± 0.014	0.041 ± 0.020	0.036 ± 0.013	0.017 ± 0.004	0.018 ± 0.005	0.015 ± 0.005
Fe	0.039 ± 0.025	0.054 ± 0.022	0.155 ± 0.059	0.052 ± 0.026	0.022 ± 0.009	0.087 ± 0.025
N	1.730 ± 0.360	1.331± 0.380	2.081 ± 0.510	1.592 ± 0.038	1.833 ± 0.017	2.001 ± 0.270
P	0.377 ± 0.037	0.353 ± 0.056	0.417 ± 0.122	0.047 ± 0.035	0.054 ± 0.036	0.102 ± 0.050

The two industrial sites showed low levels of Ca and Mg when compared with the Natural site, and this may be because Ca^{2+} and Mg^{2+} ions were leached down the soil profile in these two sites which were characterized by high moisture content compared to the Natural site. The high levels of Ca uptake by the investigated species in the Natural site were most likely correlated with the high soil Ca in the same site. This was in agreement with other reports that plants grown in high Ca nutrient solutions often contain much higher concentrations of Ca than those in solution of law Ca level [28]. On the other hand, the high levels of K uptake by the investigated species in the Natural site, which was characterizes by low levels of K when compared with the two industrial sides, suggested that K availability in the Natural site was improved by the high levels of Ca in the same site, and this was in agreement with the other findings [29,30] that Ca^{2+} ions are more strongly attracted by cation exchange than K^{+} ions. Thus more exchangeable K^{+} ions were added to the solution, and this will result in high K uptake by plants.

The relatively higher Mn levels in the Textile site, compared to the Natural site, could be a main reason behind the high concentration of Mn in the plant tissues. Moreover, the relatively high levels of Mg in the Natural site seem to depress Mn uptake [31]. Also there is another variation in Mn uptake between the species in each site, and this was in agreement with other reports [32] that different plant species showed different levels of Mn uptake. The uptake of Fe showed high variability between the species in the two sites despite similar levels of this element in the soil, and this was also in agreement with other reports [28,33] that plant species and varieties differ in their Fe uptake. On the other hand, *P. viginatum* showed different levels of Fe uptake at the two investigated sites despite similar levels of this element in the soil of the two sites; i.e., *P. viginatum* showed lower levels of iron uptake in the Natural site. These differences in Fe uptake by *P. viginatum* may be due to the effects of high Ca levels in the National site on the physiological activities of Fe. This was consistent with other

reports that high levels of Ca and Mg had negative effects on Fe physiological processes in plants [34,35 ,36].

The high levels of NH_4-N and P in the Textile site were correlated with the high organic matter content (Table 1). In other words, soil organic nitrogen and phosphorus were most likely converted to mineral forms by microbial activity [37]. The high levels of NH_4-N and P in the Textile site were reflected visually in the good performance of plant species in this site; and this was very clearly manifested by *P. viginatum* which showed greatly better performance in the Textile site than in the Natural site. On the other hand, the high levels of NH_4-N in Tannery site were duo to the ammonium compounds like NH_4Cl, $NH_4(SO_4)$ and NH_4HCO_3 which were used in the tanning activities; whereas the high levels of P in tannery site were most likely to be due to the solubility of phosphorus from its inorganic forms under the conditions of high moisture content and relatively low pH values [2,26] .

The tannery site, with no plant species, reflected the marked damage caused by the industrial chemical effluents on plant growth. Soil chemical analysis data showed that the tannery site contained very high levels of sodium and chromium ions compared to the other two sites. The toxic and osmotic effects resulted from the high levels of Na^+ ions in the tannery site could be one of the main responsible factors for the inability of plant species to get established in this site. The failure of plant species to grow when added doses of Na^+ ions reached certain levels was reported in the literature [23]; for instance, *Spinacia oleracea* and *Phaseolus vulgaris* failed to grow when added doses of Na^+ ions were equivalent to 208 and 307 mg / 100 g soil respectively. These equivalent levels of Na^+ ions were far less than those measured in the tannery site of this study, which were equal to 384 mg / 100 g soil (Table 1).

Moreover, the tannery site showed enormously higher concentration of chromium ions compared to the other two sites. High concentration of chromium ions were found to exhibit severe chlorosis, necrosis and other growth abnormalities and anatomical disorders due to its interference with enzyme activities [38]. It was found that vascular plants were highly sensitive to chromium ions, and the chromium toxic threshold to plant growth ranged between 0.05 and 1.00 mg / 100 g soil [39]. Thus the amount of chromium ions detected in the tannery site in this study (0.64 mg / 100 g soil) could be another responsible factor for the inability of plant species to get established in this site.

The distribution of *Cyperus laevigatus, Typha angustata* and *Paspalum viginatum* on the textile site is more or less correlated with moisture content and nutrient levels. *C. laevigatus* and *P. viginatum* cover the periphery of the textile site which was characterized by moderate moisture content and relatively high levels of pH, Ca, Mn and Na, and they avoid the central part of the experimental area which was characterized by high moisture content and relatively low levels of pH, Ca, Mn and Na. The central part of the textile site was mainly covered by *T. angustata.* On the other hand, the presence of *P. viginatum* and absence of *C. laevigatus* from the relatively moist areas of the Natural site, suggested that *P. viginatum* required less mineral nutrient elements than *C. laevigatus.* In addition to that, the presence of *P. viginatum* on the Textile and Natural sites clearly showed the adaptability of this species to soils of different nutrient levels, and this was in accordance with some reports on the distribution of *Trifolium repens* [40], and other legumes [41]. These distribution results of the investigated species in the Textile and Natural sites agreed with the situation envisaged in the literature that resources distribution together with local environmental heterogeneity provides the basis of the coexistence of plant species [42].

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