

Macrophytes Potentials of Indigenous Plant Species for Faecal Sludge Constructed Wetland Treatment System: A Case in the Sudano-Sahelian Context

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ABSTRACT

Constructed Wetland technology has positive potentials for the management of faecal sludge in developing countries of Sub-Saharan Africa. However, identification of indigenous plant species that can survive the high levels of faecal sludge toxicity is a major challenge to its application. Preliminary study highlighted a high complexity of potential macrophytes species identification within the Sahelian context. This study is a preliminary stage of acclimatising four indigenous plant species *Setaria verticillata* (SV), *Cymbopogon nardus* (CN), *Bambusa vulgaris* (BV) and *Typha latifolia* L. (TL) to wastewater contamination in pot experiment. Macrophytes were subjected to wastewater irrigation from maturation basin of the 2iE Ouagadougou campus wastewater treatment plant. Macrophytes growth was monitored weekly by three growth parameters (No. of Plants per pot, Plant Height and No. of Leaves per pot). Initial plant height of 46.6, 75.7 and 61.7cm for SV, BV and TL, increased to 98, 103.1 and 93.5 cm after 13, 11 and 8 weeks of planting respectively. After 11 weeks of planting the average height of CN, reduced from 66.3 to 42 cm. Number of plants averagely increased from 25 to 130, 4 to 15, 4 to 10 and 4 to 8 respectively for SV, CN, BV and TL. Average leaves per pot increased from 95 to 839, 19 to 67, 368 to 508 and 4 to 49 for SV, CN, BV and TL respectively. Variations of average growth rate among species were statistically insignificant. The results thus indicate satisfactory reed potentials with wastewater acclimatisation.

INTRODUCTION

On-site Sanitation System (OSS) up to date, still remains the principal technical solution for the difficult excreta management situation in most developing countries of Sub-Saharan Africa (SSA). The high 80 % OSS dependence has apparently resulted in large accumulations of faecal sludge in pits and vaults.

Constructed wetland (CWL) technology appears as a novel treatment option for the effective management of faecal sludge (FS). This is mainly due to its low energy requirements, reduced operation and maintenance costs, with little environmental impact (Uggetti *et al.*, 2009). The technology has extensively been applied in many

regions of the world for wastewater treatment, which operates with basically beds or trenches filled with a gravel layer and planted with emergent rooted wetland vegetation (Cole, 1998; Caselles-Osorio *et al.*, 2007; Uggetti *et al.*, 2009). Current research works (Kengne *et al.*, 2008; Kengne *et al.*, 2009; Kengne *et al.*, 2012; Kouawa *et al.*, 2015) have thus been oriented toward the exploitation of the CWL system for the treatment of faecal sludge to help salvage the current FS management situation in the African context.

Plants are key elements of the CWL treatment system, since they contribute to sludge dewatering mainly by evapotranspiration and enhances

mineralisation through the transport of oxygen from the aerial parts to the belowground biomass, creating an aerobic micro-sites and thereby ensuring aerobic degradation processes and other includes *Phragmites sp.* (Reeds), *Typha sp.* (Cattails), *Cyperus papyrus* (Papyrus) and *Echinochloa sp.* (Nielsen, 2005; Koottatep *et al.*, 2005; Kengne *et al.*, 2008).

Unlike wastewater, faecal sludge exhibits higher concentration of pollutants which might be toxic for the growth and development of selected macrophyte (Strande *et al.*, 2014).

Identification of indigenous macrophyte species, most likely to withstand the high levels of FS toxicity is a major challenge with regards to application of the CWL technology in a local context. The premier study in Ouagadougou by Kouawa *et al.* (2015), observed total wilting of two indigenous plant species thus *Oryza longistaminata* and *Sporobolus pyramidalis* when FS was loaded after wastewater for acclimatisation. To ensure optimum operation of the CWL treatment technology, preliminary research feasible in a local situation is strongly recommended prior to full scale implementation (Kouawa *et al.*, 2015).

This study is thus a preliminary stage of acclimatising four different indigenous plant species *Setaria verticillata* L. (SV), *Cymbopogon nardus* (CN), *Bambusa vulgaris* (BV) and *Typha latifolia* L. (TL) to wastewater contamination in a pot experiment.

MATERIALS AND METHODS

Study Area

This study was carried out at the International Institute of Water and Environmental

oxygen dependent reactions such as nitrification. Typical macrophytes species commonly used at pilot scale research

Engineering (2iE) Ouaga campus in Ouagadougou, Burkina

Faso, located within the Sudano-Sahelian ecological zone. Mean annual rainfall ranges between 600 to 900 mm within the period of May to October (Ibrahim *et al.*, 2012). An average temperature, between 25 to 28 °C is generally experienced (USAID, 2017) while the maximum range of 42° to 43 °C can be attained at the hottest season of Harmattan. The monsoon and Harmattan are the two main principal factors that influence the climate characteristics in Ouagadougou.

The study was within the period of June to September, 2017.

Selection of Indigenous Plant Species

The principal criteria for selection of potential species include growth in swamps and preferably wetlands with human induced contamination (wastewater stagnations/ drainage routes) with potential economic significance and positive environmental impact. Four different indigenous plant species were selected for the study and they include Bristly foxtail (*Setaria verticillata* L. P. Beauv.), Citronella grass (*Cymbopogon nardus* L. Rendle.), Bamboo (*Bambusa vulgaris*) and Broad leaf cattails (*Typha latifolia* L.) Locations of the selected species are presented in Figure 1 whilst Table 1 presents a summary of the biological classification of selected species.

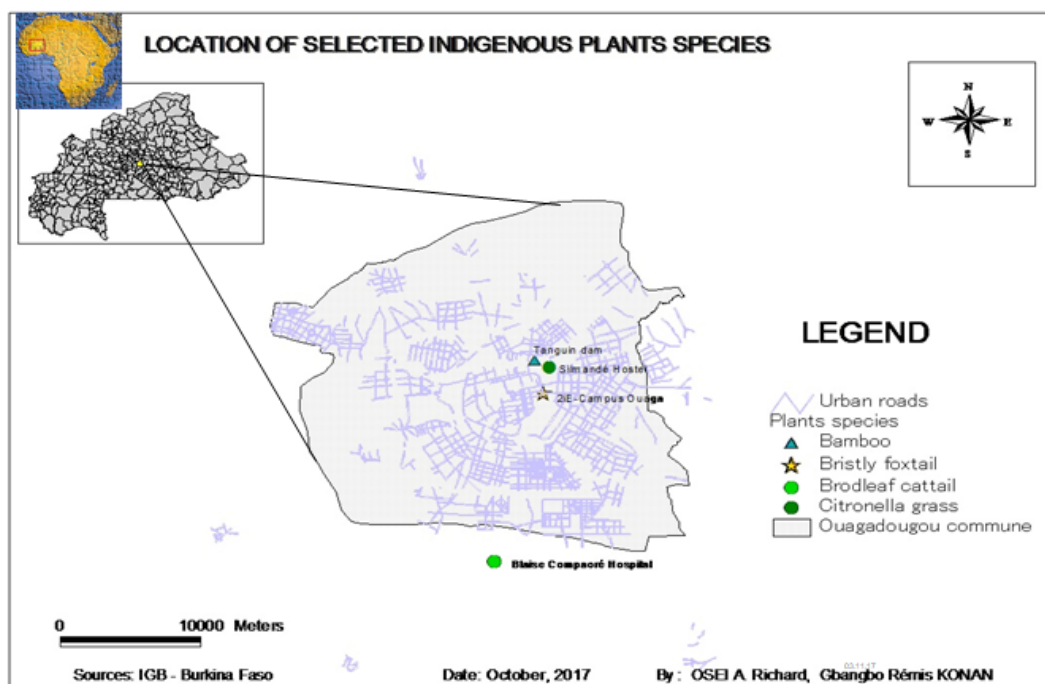


Figure 1: Location of Selected Indigenous Plant Species

(Extracted and modify from IGB-Burkina Faso, 2017)

TABLE 1: Biological Classification of Selected Indigenous Plant Species

Taxonomic Hierarchy	Species Common Name			
	Broad leaf cattails	Bristly foxtail	Bamboo	Citronella grass
Domain	Eukaryota	Eukaryota	Eukaryota	Eukaryota
Kingdom	Plantae	Plantae	Plantae	Plantae
Subkingdom	Tracheobionta	Tracheobionta	Tracheobionta	Tracheobionta
Phylum	Spermatophyta	Spermatophyta	Spermatophyta	Spermatophyta
Subphylum	Magnoliophyta	Angiospermae	Angiospermae	Magnoliophyta
Class	Liliopsida	Monocotyledonae	Monocotyledonae	Monocotyledonae
Subclass	Commelinidae	Commelinidae	Commelinidae	Commelinidae
Order	Typhales	Cyperales	Cyperales	Cyperales
Family	Typhaceae	Poaceae	Poaceae	Poaceae
Genus	Typha L.	Setaria	Bambusa	Cymbopogon
Species	<i>Typha latifolia</i> L.	<i>Setaria verticillata</i> L. P. Beauv	<i>Bambusa vulgaris</i> Schrad. ex J. C. Wendl.	<i>Cymbopogon nardus</i> L. Rendle

Composition of Pilot-Scale Constructed Wetland

To ensure comparable conditions of a typical constructed wetland, a 27 litre plastic container (47:34:25.5 cm) was filled up to 15 cm of sand (ϕ : uniformity coefficient = 2.5 and $d = 0.27$ mm) supported at the base with 5 cm layer of gravels (ϕ : 3.3 - 16 mm) with a free board of 5.5 cm. An under drain with a regulatory tap was attached to the base of the container to ensure dewatering. Both bedding materials (sand and gravels) were thoroughly washed prior to filling.

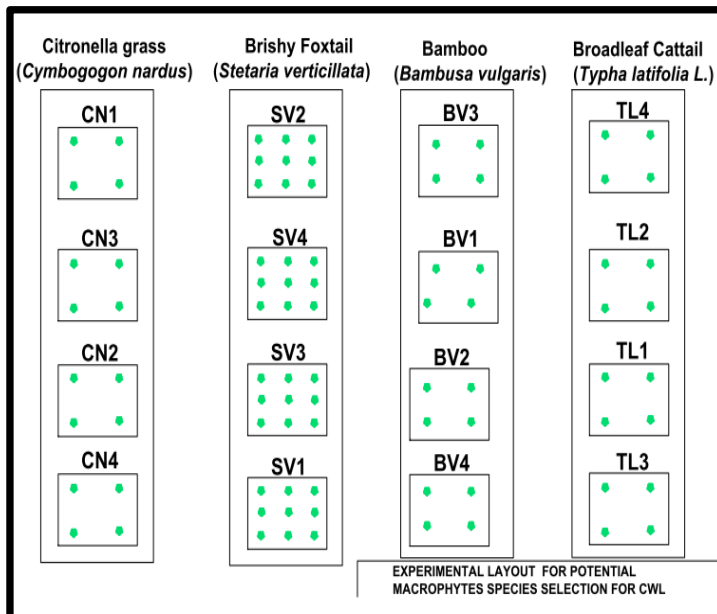
Propagation Materials for Selected Species

Materials for propagation consisted of young shoots with an average height of 47, 66 and 76 cm

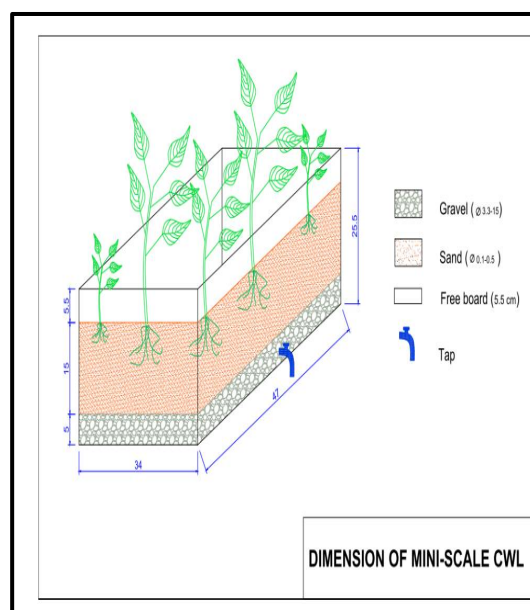
for Bristly foxtail, Citronella grass, and Bamboo respectively. Cuttings were prepared from matured Broad leaf cattails to an average height of 62 cm. Transplanting was carried out within 24 hours after harvesting.

Experimental Design

The experimental layout consists of 4 experimental units (pots) per plant species in a completely randomized design (CRD). Planting arrangement was in the order of 4 plants per pot for both Citronella grass and Broad leaf cattails whilst Bamboo and Bristly foxtail consisted of 3 and 9 tufts respectively per pot. The experimental layout and arrangement of Pilot-Scale CWL is presented in Figure 2.



CN: *Cymbopogon nardus* L. SV: *Setaria verticillata* BV: *Bambusa vulgaris* TL: *Typha latifolia* L.



a) Experimental Layout

Figure 2: Experimental Layout and Arrangement of Pilot-Scale CWL

b) Pilot-Scale CWL

(Field Design, 2017)

Wastewater Irrigation and Physico-chemical Parameters

Wastewater was collected from maturation ponds of 2iE Ouagadougou Campus wastewater treatment system. The system consists of a single set anaerobic, facultative and maturation pond connected in series, which utilises natural stabilisation processes for the treatment of wastewater (mainly greywater, and blackwater) generated at the Ouagadougou campus. Each pot was saturated with 6 litres of wastewater per day. Irrigation was scheduled for 3 days continuously

and allowed for 2-3 days of rest depending on antecedent moisture conditions.

The quality of wastewater used for irrigation was monitored for concentration of general physico-chemical parameters (Table 2). Temperature, pH, Eh, Conductivity, DO, Salinity and TDS were determined by Multiparameter HANNA instrument (HI 9828). All other parameters were determined in accordance with the recommendations of the standard methods for the examination of wastewater and sludge (APHA, 2005).

TABLE 2. Physico-Chemical Characteristics of Wastewater used for Acclimatization

Parameters	Mean	SD (\pm)	Min.	Max.	Median
Temp. ($^{\circ}$ C)	27.00	0.66	26.33	27.76	26.98
pH	7.61	0.10	7.50	7.75	7.59
Eh (mV)	8.63	5.17	1.50	13.40	10.20
EC (μ S/cm)	416.83	29.96	381.00	457.00	420.50
DO (mg/l)	1.42	0.38	0.86	1.83	1.39
Sal (PSU)	0.20	0.02	0.18	0.22	0.20
Turbidity (NTU)	249.83	177.27	127.00	592.00	191.00
TDS (mg/l)	216.17	36.48	190.00	288.00	202.50
TSS (mg/l)	69.67	12.29	50.00	88.00	70.00
TS (mg/l)	285.83	27.70	260.00	338.00	279.50
COD (mg/l)	244.67	74.25	160.00	362.67	231.67
NO ₃ ⁻ -N (mg/l)	1.67	0.15	1.50	1.80	1.70
NO ₂ ⁻ -N (mg/l)	0.003	0.001	0.002	0.005	0.004
NH ₃ -N (mg/l)	15.85	1.70	13.40	17.40	16.65
PO ₄ ³⁻ -P (mg/l)	7.68	1.26	6.50	9.20	7.25

(Field Survey, 2017)

Assessment of Species Growth Parameters

A weekly assessment of species growth and development was performed for number of plants

and number of leaves by count, and plant height using standard (3m/10ft) tape measure. Development of bamboo culm size was

monitored weekly with the aid of a pair of dividers and a standard (15 cm) ruler. The weekly variation of culm diameter was measured for 3-6 internodes (depending on the average height) per plant. Culm size was determined by Equation 1.

$$CS = \pi d \quad (1)$$

Where; CS = Average bamboo culm size and d = Average culm diameter.

Data Analysis

Weekly measurements of species morphological development were subjected to trend analyses and plotted with Minitab 16.2.1 and Microsoft Excel 2010. Statistical significance of the variation of average growth rate among species was determined by analyses of variance (ANOVA) at 5 % level of significance ($F_{pr} < 0.05$) with Genstat software (ninth edition).

RESULTS AND DISCUSSIONS

Performance of *Setaria verticillata* (Bristly Foxtail) to Wastewater Acclimatisation Plant Height

For the period of study, average plant height for *Setaria verticillata* per each experimental unit rapidly increased from below 50 cm in the third week to a maximum of 98 cm in the tenth week (Figure 3). Height development, however, started to decrease from the eleventh to thirteenth week, ending with an average of 84.3 cm. The period of progression (from week 1 to 10) statistically translates into a weekly growth of 5.2 (± 2.9) cm. The slow plant height development within the first three weeks might relate to the duration of adaptation to the constructed wetland conditions, after which a more stabilised stage of rapid shoot development was obtained. The reduction from the eleventh week was coupled with rapid panicle development and thus indicating *Setaria verticillata* attainment of full maturity. Mavioso and Galvão (2013) similarly observed a slow adaptation growth of two species (*Phragmites australis*, and *Scirpus*) and pointed to the vegetation's growth cycle, as a possible reason.

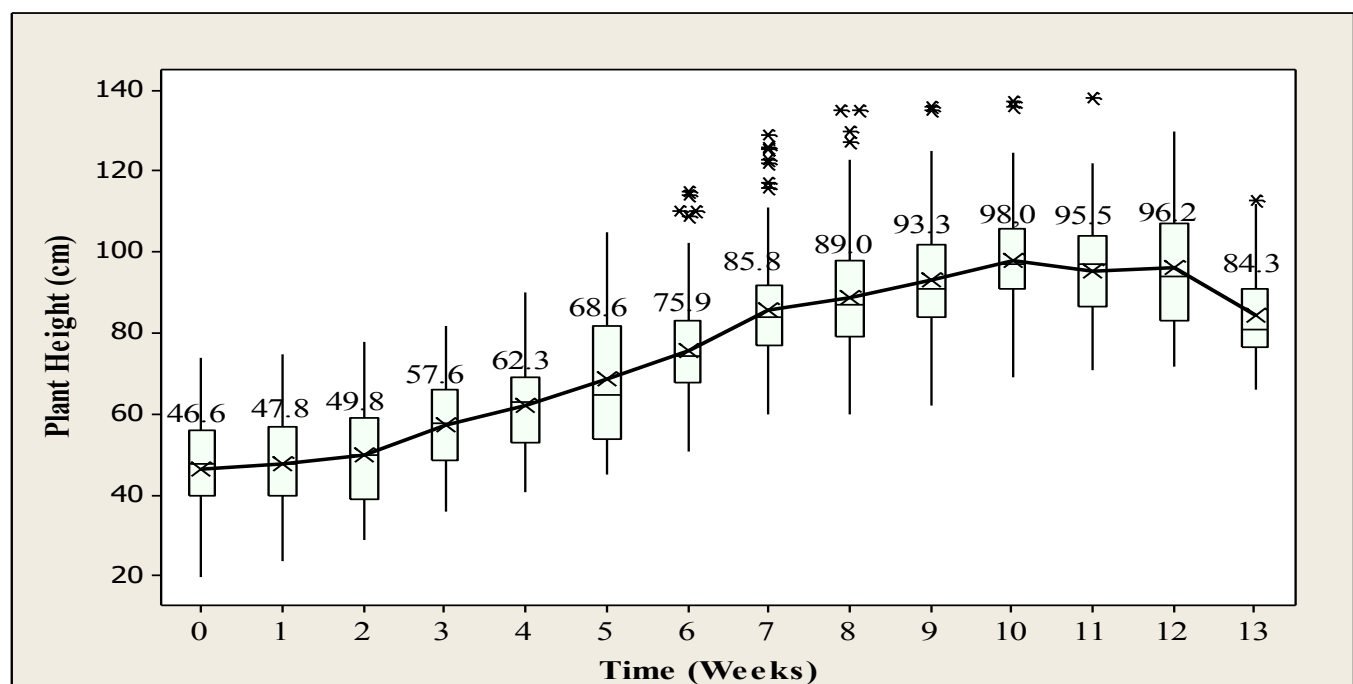


Figure 3: Weekly Average Plant Height Development of *Setaria verticillata*

(Field Survey, 2017)

Number of Plants

Wastewater acclimatisation of *Setaria verticillata* was noticeable with rapid shoot development (Figure 4). The number of plant steadily increased from a minimum average of 25 to a maximum of 130 plants per pot at eleventh week after planting. As generally observed, a decline in week 12 and 13 was observed. The trend translates into a weekly increment of 11 (± 6) plants per experimental unit from the first to the eleventh week. Adaptation to the constructed wetland conditions and attainment of maturity might as well be the principal factors for the relatively slow development within the first three weeks and the decline at the final stages, respectively.

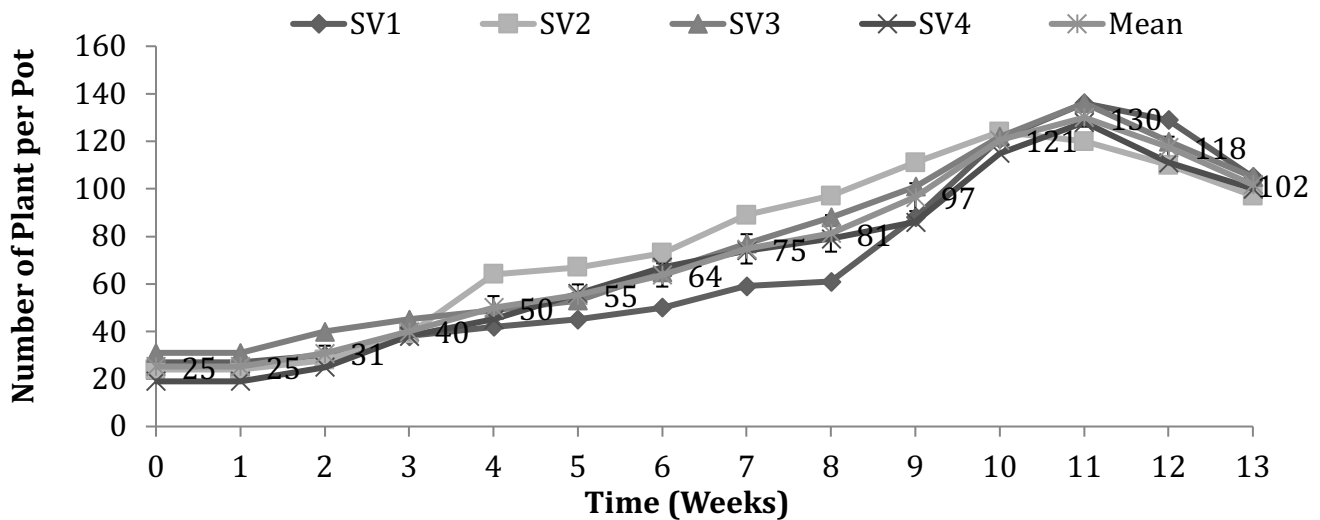


Figure 4: Weekly Growth of Number of Plants for *Setaria verticillata*
(Field Survey, 2017)

Number of Leaves

Number of leaves progressively increased from an initial average of 95 leaves per pot to a maximum of 839 leaves in the tenth week, which was then followed by a gradual decline from 798 to 673 leaves from the eleventh to thirteenth week respectively (Figure 5). An average of 77 (± 44) leaves per pot was added per week for the period of rapid development (week one to eleven). Symptoms of leaf wilt were observed, especially for mature plants after the tenth week. As earlier noted, the growth cycle might be the reason for the observation.

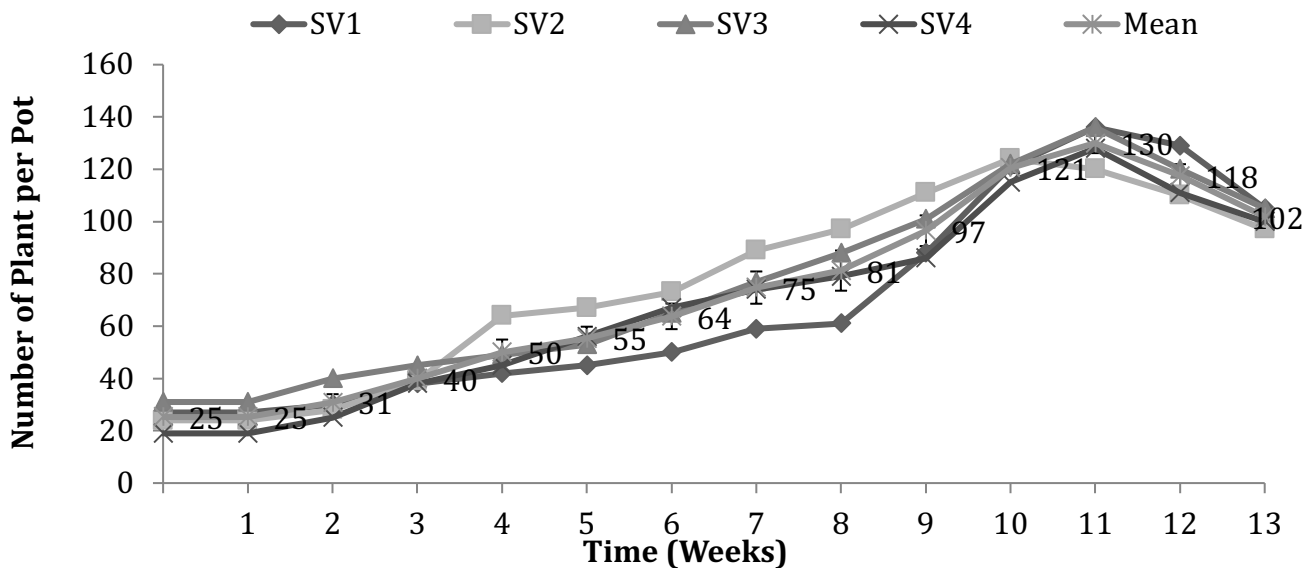


Figure 5: Weekly Average Number of Leaves Development of *Setaria verticillata*
(Field Survey, 2017)

Emergence of Spikes

The acclimatisation of *Setaria verticillata* to wastewater irrigation was as well characterised with the emergence of spikes. A minimum average of 10 spikes per experimental unit was initially observed, six weeks after planting (Figure 6). The successive weeks were consequently characterised by rapid spikes emergence with the exception of week twelve and thirteen which in contrast decreased. The maximum average of 304 spikes was recorded on the eleventh week but, was however, reduced to 239 at the end of the study period. Based on Allred (1982) general description of grass inflorescence, the flower type for *Setaria verticillata* was in the category of generalised spike inflorescence. They exhibit determinate growth pattern of the overall flowering shoot, with most mature spikelets toward the apex and least mature toward the base.

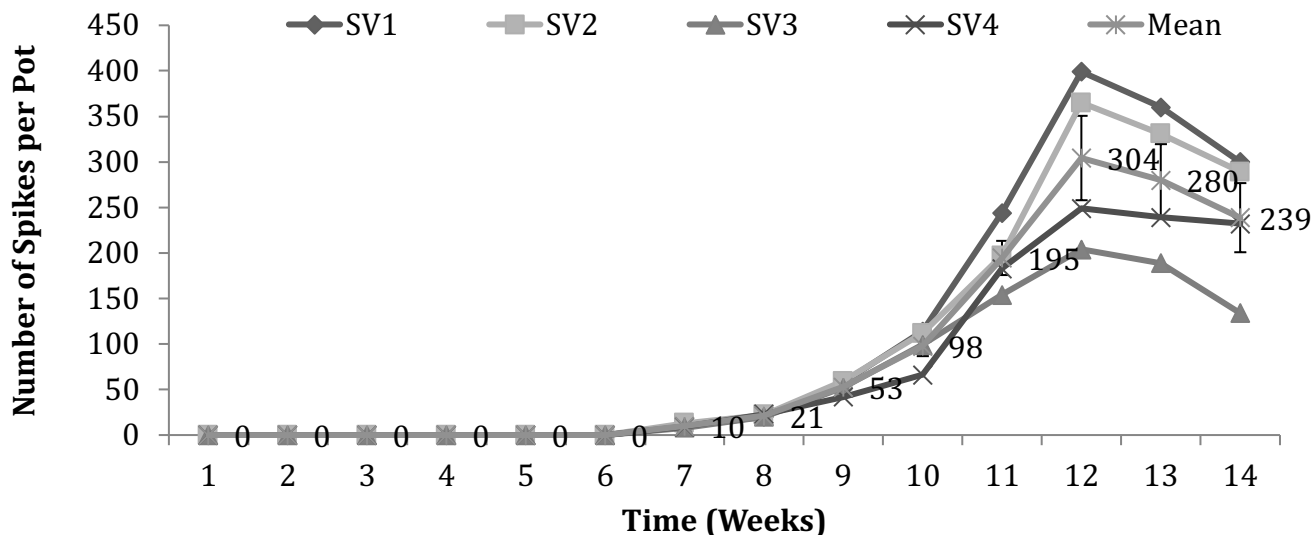


Figure 6: Weekly Average Panicle Number Development of *Setaria verticillata*
(Field Survey, 2017)

Setaria verticillata is generally described as a loosely tufted annual grass, with an average height of up to 1 m high, and often rooting at the lower nodes (Parker, 2008). It is known to easily adapt to a wide range of soil types of low and high fertility, ranging from pH of 6.1 to 8.0 and thus easily occurs on roadsides and in waste places over a wide ecological range. In the younger, vegetative stages, *Setaria verticillata* could provide palatable and nutritious forage for livestock (Parker, 2008). The rapid growth of *Setaria verticillata* for the period under review might be attributed to positive adaptability to the conditions of the constructed wetland.

Performance of *Citronella nardus* (Citronella grass) to Wastewater Acclimatisation

Plant Height

Distinctively from the other species, wastewater acclimatisation of *Citronella nardus* was generally characterised by wilting of the initial (aged) leaves for the sprouting up of new shoots. The average height, after virtually recording no development two weeks after planting, significantly reduced from above 60 cm to a minimum of 38.4 cm in the sixth week (Figure 7). The successive weeks, however recorded a gradual height increase up to 42 cm in the eleventh week after planting.

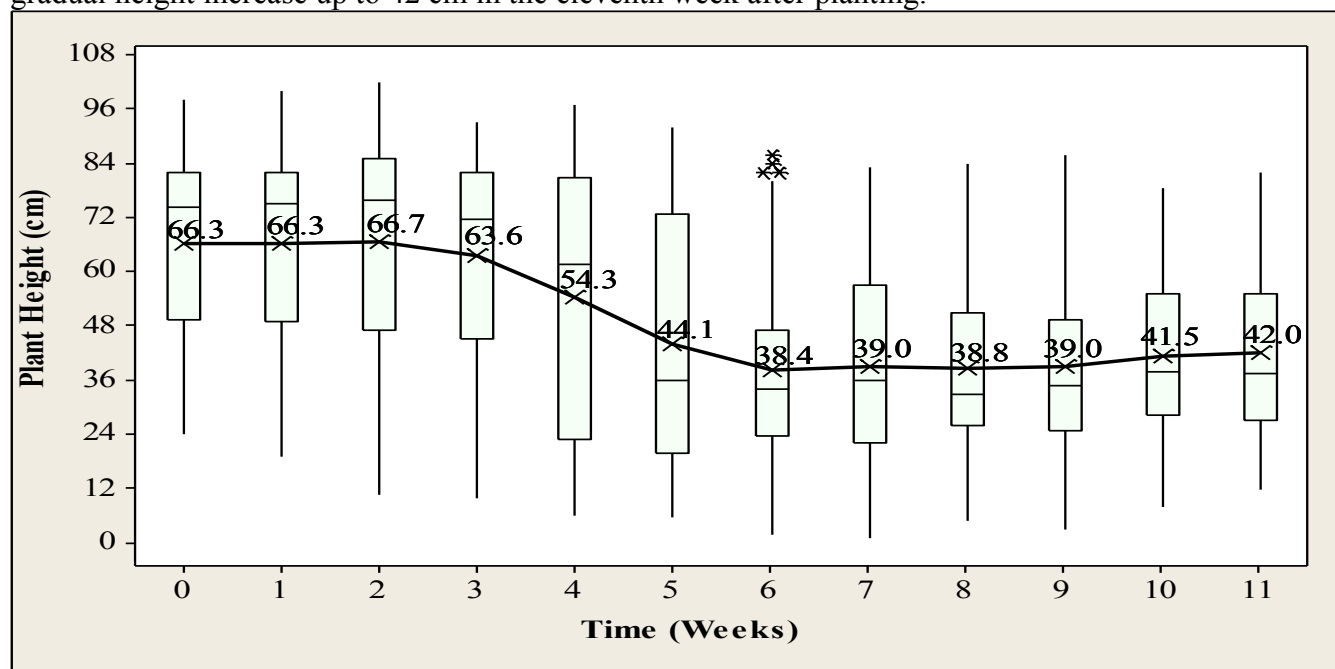


Figure 7: Weekly Average Plant Height Development of *Citronella nardus*
(Field Survey, 2017)

Irrespective of the complexity exhibited by *Citronella nardus* acclimatisation was complemented by development of new shoots. This was realised to have occurred one month after planting (Figure 8). Despite the disparities among the experimental units, the average maximum of 15 plants per experimental unit was stabilised from the sixth week to the end of the study period. The experiment however, commenced with a minimum average of 4 plants per pot. New shoots sprouted around parent in the form of clumps. As described by Scutti (2013), *Citronella nardus* is a perennial clump-forming tropical grass which could grow up to 1.5-1.8 m tall with canelike stems.

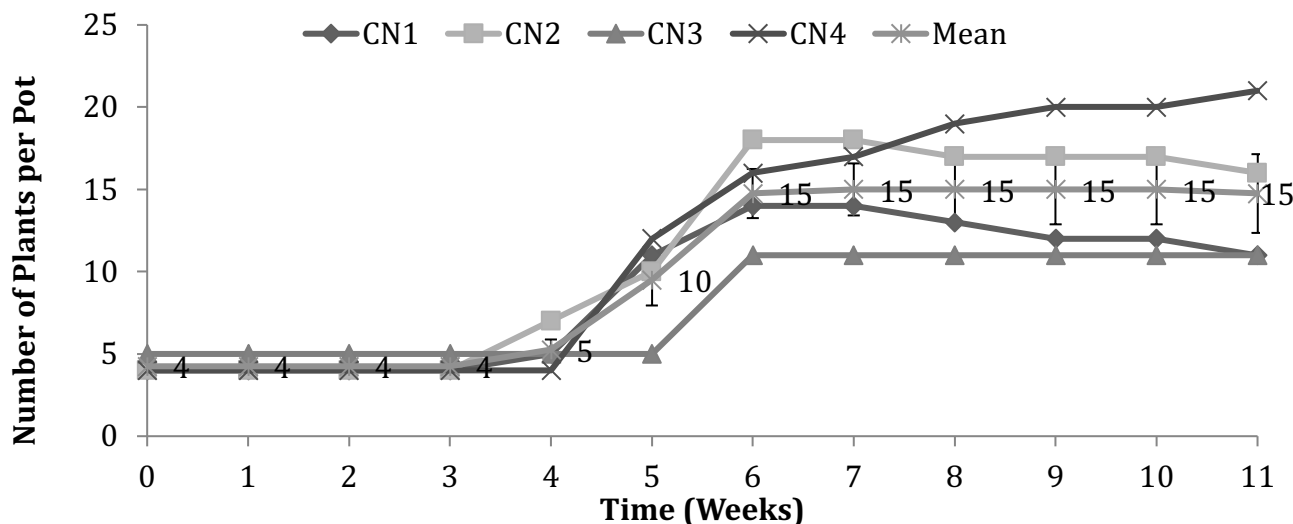


Figure 8: Weekly Number of Plants Growth of *Citronella nardus*
(Field Survey, 2017)

Number of Leaves

For a period of one month, *Citronella nardus* virtually recorded no new leaf development. Nonetheless, a substantial growth was observed from week six to the eleventh week (Figure 9). This thus, resulted to a maximum average of 67 leaves per experimental unit at the end of the study, from an initial average of 19 leaves.

Citronella nardus leaves are usually described as flat, about 0.9 m long and greyish green in colour. It is generally considered as a low maintenance, like most grasses, and they do best in full sun and well-drained locations (Scutti, 2013). *Citronella nardus* usually is used as herbal mosquito repellent (Rani *et al.*, 2013). *Citronella* could thus be mentioned to have positively adapted well to wastewater acclimatisation.

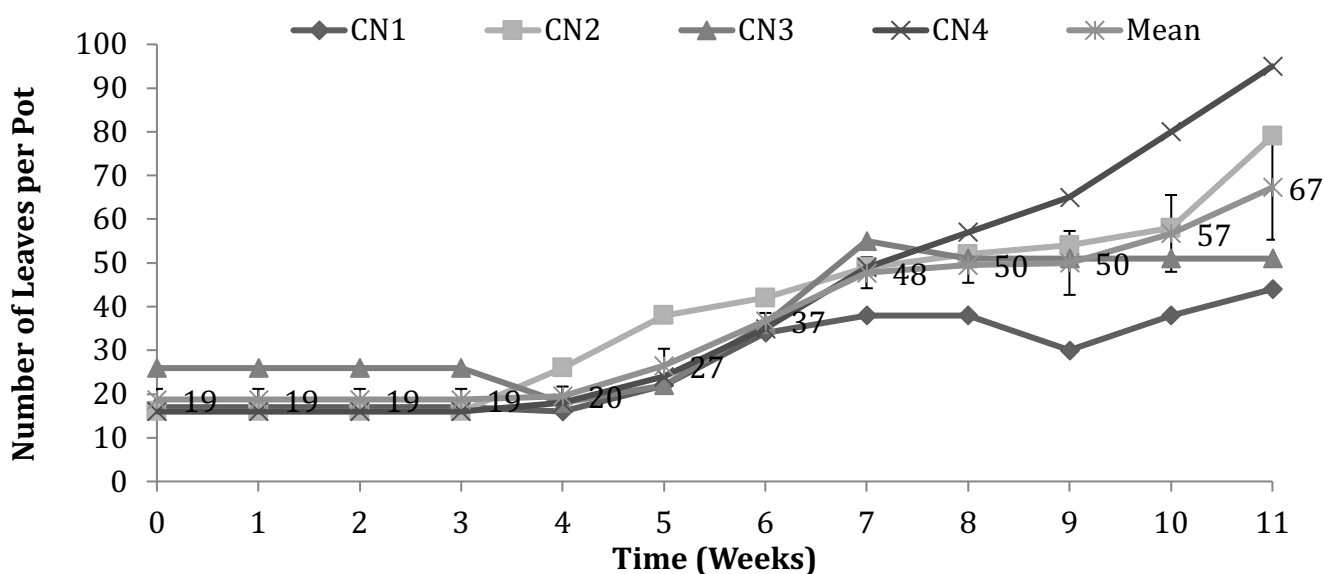


Figure 9: Weekly Average Number of Leaves Development of *Citronella nardus*.
(Field Survey, 2017)

Performance of *Bambusa vulgaris* (Bamboo) to Wastewater Acclimatisation

Plant Height

Generally, the growth of *Bambusa vulgaris* responded positively to the application of wastewater. From an initial average height of 75.7 cm, *Bambusa vulgaris* progressively increased to a maximum of 103.1 cm at the end of the study (Figure 10). From the second to the eighth week, height development corresponded to a weekly average rate of 6.8 (± 2) cm per pot. The development of height apparently commenced from the fourth week to the end of the study period, after recording a relatively slow pace for the previous weeks. Adaptation to the CWL medium might have accounted for the slow pace.

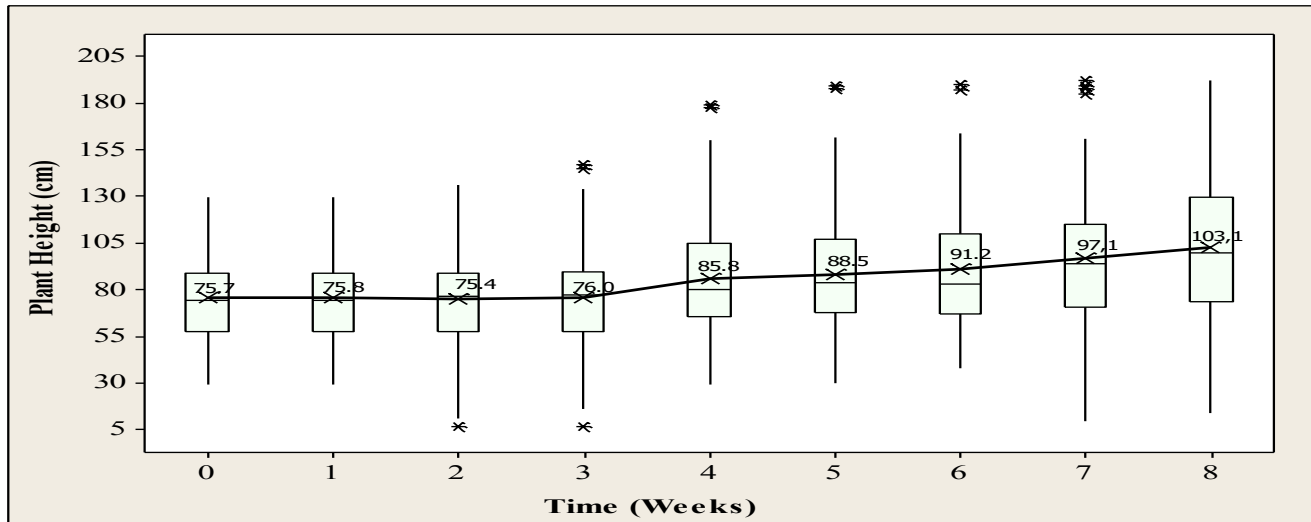


Figure 10: Weekly Average Plant Height Growth of *Bambusa vulgaris* (Field Survey, 2017)

Number of Plants

Development of new shoots was observed for *Bambusa vulgaris* during the period of study. From the second week onwards, *Bambusa vulgaris* virtually recorded a weekly emergence of 1 shoot per pot (Figure 11). An initial average of 4 plants per pot progressively increased to a maximum of 10 at the end of the study period.

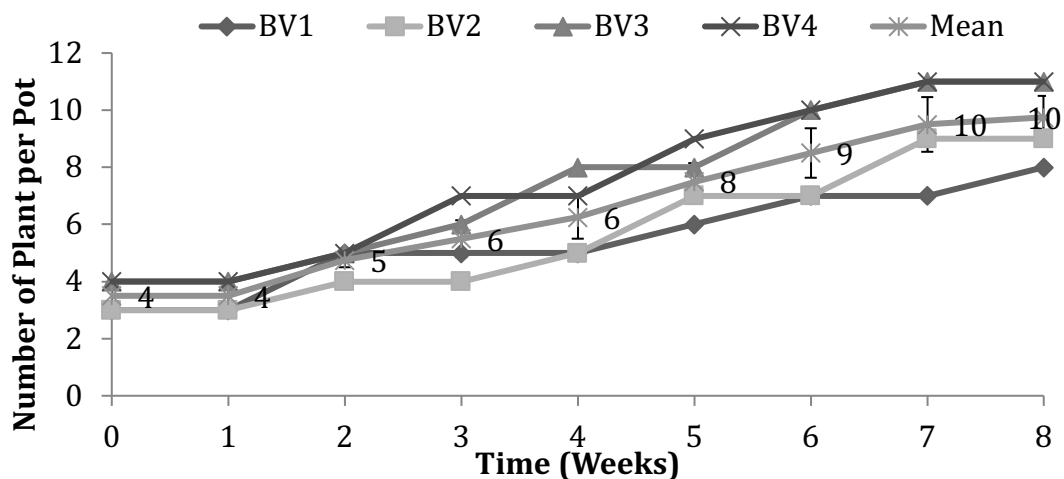


Figure 11: Weekly Number of Plants Development of *Bambusa vulgaris* (Field Survey, 2017)

Number of Leaves

Bambusa vulgaris also recorded an increase in the number of leaves. At the beginning of the experiment, a minimum average of 368 leaves per pot was observed to have increased to a maximum of 508 leaves (Figure 12). The trend of average leaf number statistically corresponds to a weekly increment of 18 leaves per experimental unit with a standard deviation of ± 8 . Weekly variation of the number of leaves was significantly influenced by frequent wilting and dropping of mature leaves, as a physiological characteristic of *Bambusa vulgaris*. According to Boness (2016), the yellowing and dropping of bamboo leaves are normal physiological processes throughout the year.

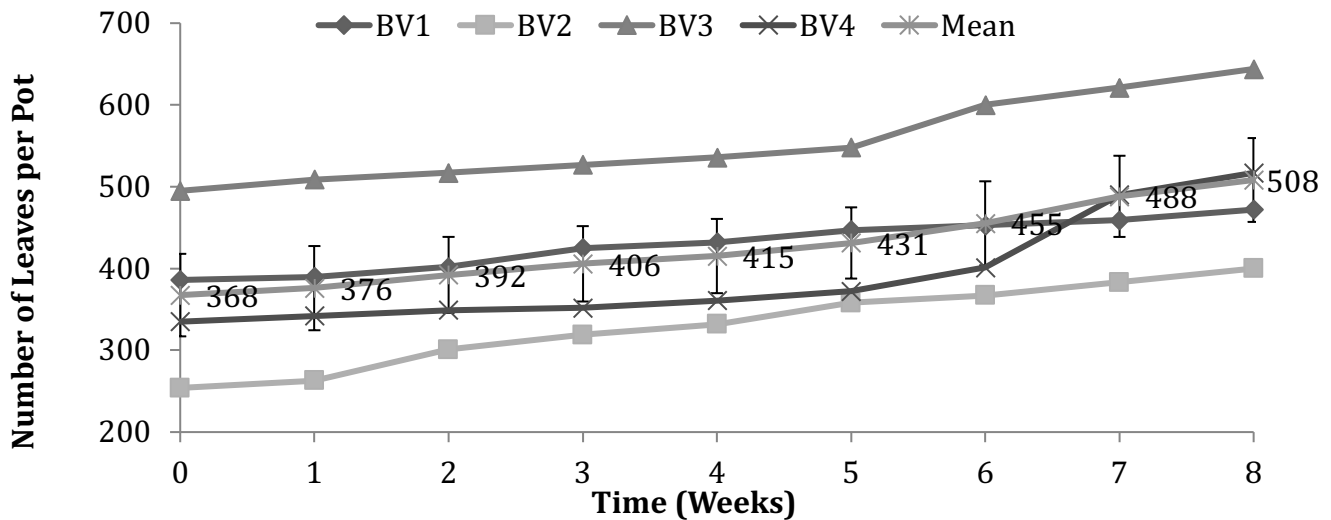


Figure 12: Weekly Average Number of Leaves Development of *Bambusa vulgaris*
(Field Survey, 2017)

Culm size

The study generally observed an increasing trend in the size of *Bambusa vulgaris* culm. The result (Figure 13) reveals a maximum average culm of 2.3 cm at the end of the period of study, from an initial average of 1.9 cm per experimental unit. The period of adaptation of *Bambusa vulgaris* to the CWL conditions might be accountable for the insignificant increase in average culm size, two weeks after planting.

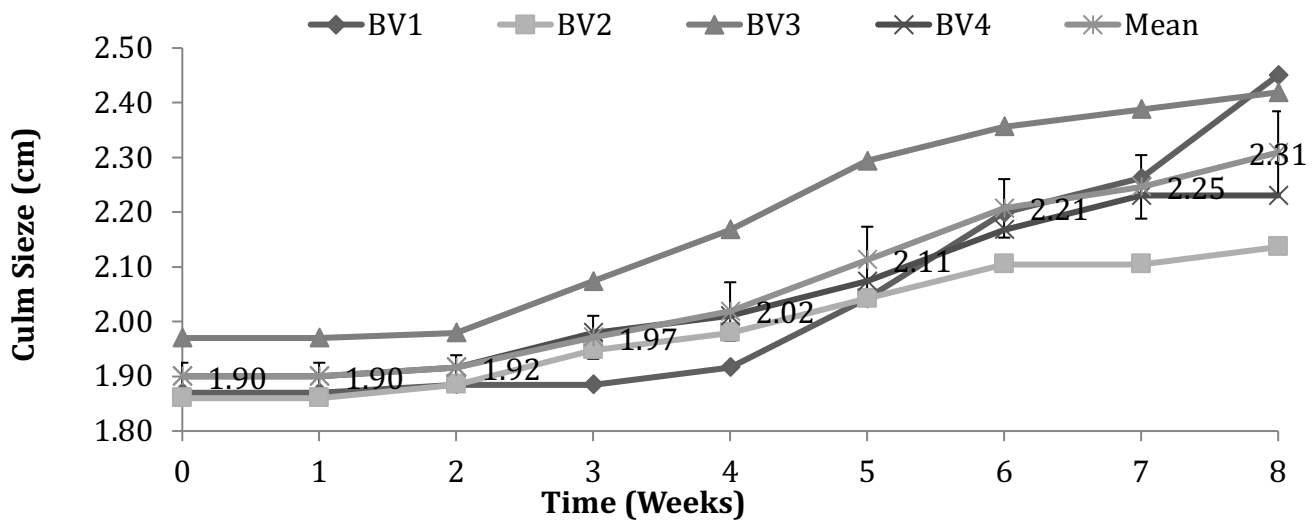


Figure 13: Weekly Average Culm Size of *Bambusa vulgaris*
(Field Survey, 2017)

Bambusa vulgaris is generally classified as one of the fastest growing plant species with growth rate up to 1.2 m per day. Soil pH in the range of 4.5 to 7.0 is optimal for *Bambusa vulgaris* development (Thokchom and Yadava, 2015). *Bambusa vulgaris* can survive a wide range of temperature from 8.5 °C to 36.0 °C. Depending on species type, erect culms reach up to 30 m tall. The rapid growth thus, corresponds with consumption of enormous quantities of carbon dioxide while significant quantity of oxygen (35 % more oxygen than a similar stand of trees) is produced (Bamboo Information Network, 2011). *Bambusa vulgaris* has numerous applications which include its use in the building industry, for the production of various woody objects and for medicinal purposes (Islam *et al.*, 2011).

For the period of the study, *Bambusa vulgaris* can be said to have good adaptability to wastewater acclimatisation due to the total improvement of the growth parameter considered for the study. Brix (2003) explained that plants are morphologically adapted to growing in wetland conditions by virtue of large internal air spaces for transportation of oxygen to roots and rhizomes. Zachariah *et al.* (2016) also noted that bamboos have aerenchyma structures and generally sequester carbon primarily due to their relatively high growth rate among other plants. Pulavarty and Sarangi (2015), after realising high salt tolerant for three different bamboo species mentioned that, utilization of this species for pollution management might

have significant environmental benefits and ecological gain due to its diverse utility in the domestic and industrial sector.

Response of *Typha latifolia* L. (Broad Leaf Cattails) to Wastewater Acclimatisation

Plant Height

Similar to the other species, the average height of *Typha latifolia* L. generally increased for the period of study. Initial average height after a slight increase from 61.7 to 72.5 cm a week after planting, gradually reduced from the second week to a minimum of 51.3 cm in the third week. The subsequent weeks, however, recorded an appreciable increase, ranging from 62.9 to 93.5 cm from the fourth to the eighth week respectively (Figure 14). The period of progressive increase (from week 3 to 8), statistically corresponded to an average growth of 8.4 cm per week, with a standard deviation of ± 4.8 .

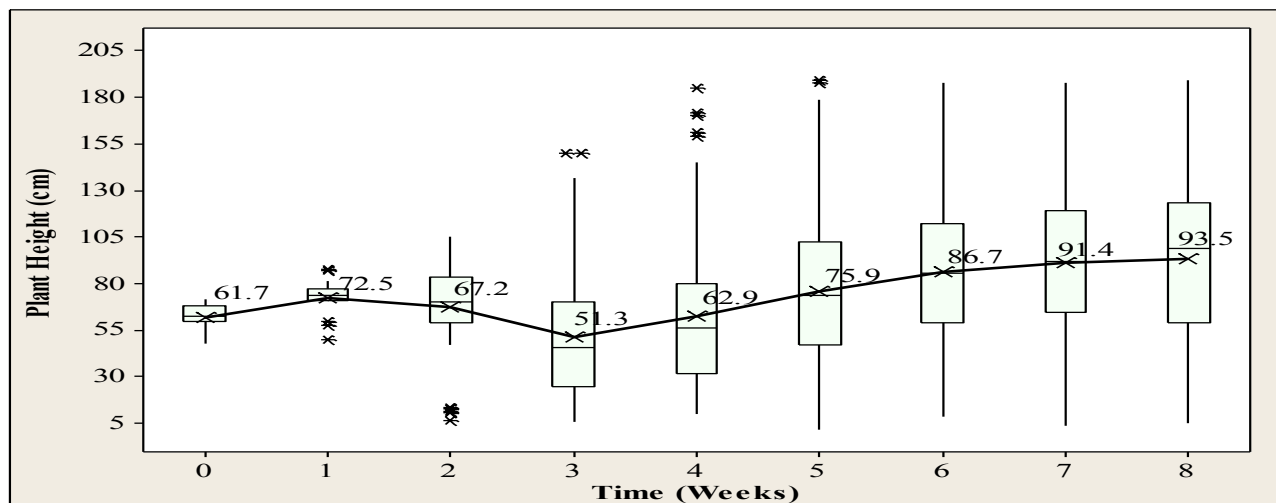


Figure 14: Weekly Development of Average Plant Height for *Typha latifolia* L. (Field Survey, 2017)

The increased plant height at the first week was due to the continuous development of the transplanted stalk. The observed decline during the second and the third week was mainly because of the vigorous development of new shoots from underground rhizome reproduction. It is worth noting that, relatively longer leaves usually dropped off conceivably, by the effect of wind. The influence of wind on plant growth and development is interpreted within the context of stress and strain relationships by Telewski (2004), where a primary stress is applied to the leaves resulting from an applied force of the wind.

Number of Plant

As already mentioned, new shoots of *Typha latifolia* L. for the period of study continuously emerged from underground rhizome reproduction. From an initial average of 4 plants, the *Typha latifolia* L. gradually increased to a maximum of 8 plants per pot for the period of study (Figure 15). There was an average addition of one per plant weekly for the period between the second and fifth week. The development of new shoots was coupled with wilting of the matured stalk used for propagation, and thus might be a principal factor for the weekly accounts of the number of plants, most especially during the sixth week.

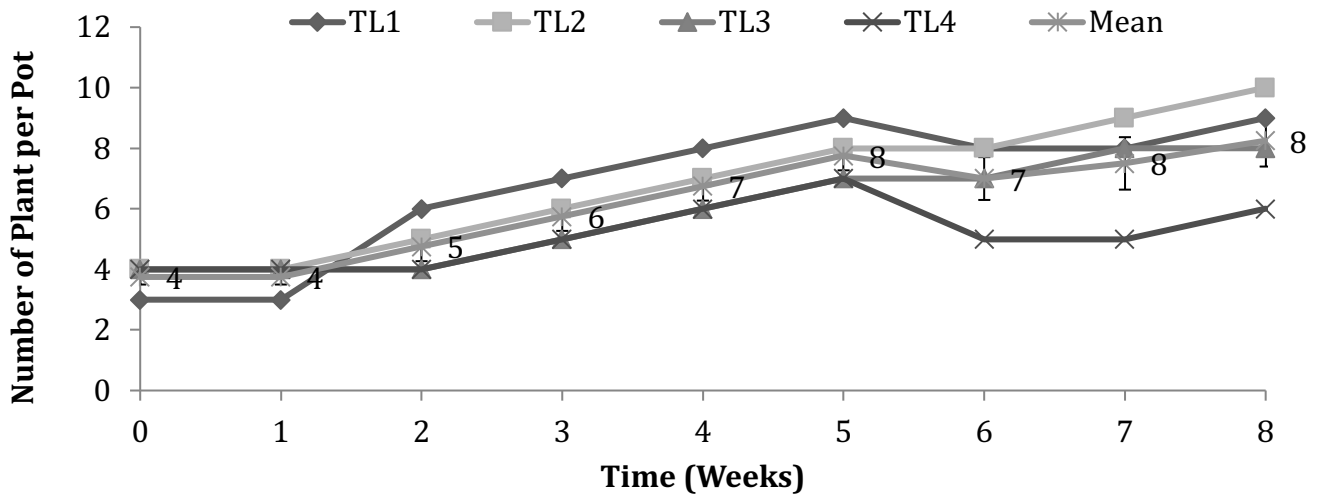


Figure 15: Weekly Number of Plants Development of *Typha latifolia* L.
(Field Survey, 2017)

Number of Leaves

Typha latifolia L. was characterised by vigorous development of fresh leaves. From an initial average of 4 leaves per pot, the number of leaves steadily increase to a maximum of 49 at the end of the study period (Figure 16). The increasing trend accounts for a weekly growth of 6 (± 4) fresh leaves per pot. The phenomenon of leaf drop can thus not be overlooked.

Downard *et al.* (2017), described *Typha latifolia* L. as generally, wetland plants with basal, erect flat leaves up to 1-3 m tall and pale greyish-green in colour. A single shoot is known to produce between 12 – 16 leaves. The root system comprises of thick long rhizomes which can grow up to 0.6 to 3 cm in diameter and as deep as 10 cm. Production of new shoots by underground rhizome division is typical of *Typha latifolia* L. According to Varma *et al.* (2017), plants of the genus *Typha* have morphological characteristic of extensive aerenchyma that functions effectively for aeration of the rhizosphere and promote fungal colonisation in a flooded or wetland condition.

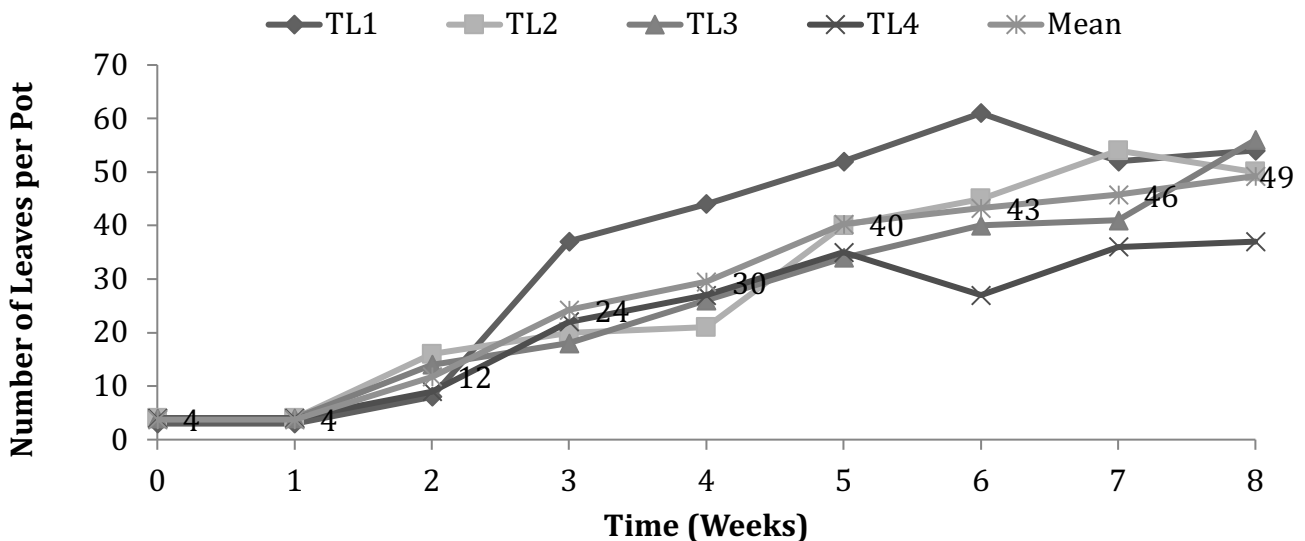


Figure 16: Weekly Average Number of Leaves Development of *Typha latifolia* L.
(Field Survey, 2017)

Typha latifolia L. can help reduce pollution of heavy metal such as lead, zinc, copper and nickel. The various parts (pollen, rhizomes and young shoots or spikes) serves as a raw material for the production of woven mats, roofs, bedding, chairs and hats and stuffing for pillows and diapers (Morgan and Sytsma 2009; Hansen, 2012).

Rate of Macrophyte Development

The average rate of macrophyte development was estimated (per week) for the growth parameters (Table 3). TL recorded the highest average rate of 4.0 ± 10.1 followed by BV and SV at 3.4 ± 3.5 and 2.9 ± 5.5 cm/week respectively for plant height development. The dynamics of CN however resulted to a

decreasing rate of 2.2 ± 4.3 cm/week. Variation among species was realized to be statistically insignificant with Fpr of 0.1. Kouawa *et al.* (2015), in a similar experiment recorded insignificant difference for plant growth among *Oryza longistaminata* and *Sporobolus pyramidalis* (from the Poaceae family) with relatively higher rates of 1.3 and 1.1 cm/day respectively.

Table 3: Average Rate of Macrophyte Species Development

Species	Period (Weeks)	Average Growth Rate		
		Plant Height (cm)	No. of Plants	No. of Leaves
SV	13	2.9 \pm 5.5	6 \pm 11	44 \pm 67
CN	11	-2,2 \pm 4.3	1 \pm 2	4 \pm 5
BV	8	3.4 \pm 3.5	1 \pm 1	18 \pm 8
TL	8	4.0 \pm 10.1	1 \pm 1	6 \pm 4
Fpr (<0.05)		0.103	0.13	0.06
LSD		5.7	8	36

CN: *Cymbopogon nardus* L. SV: *Setaria verticillata* BV: *Bambusa vulgaris* TL: *Typha latifolia* L.

(Field Survey, 2017)

For the weekly emergence of new shoots (No. of plant), SV recorded the highest rate of 6 ± 11 shoot/week whilst CN, BV and TL recorded equivalent rate of 1 shoot/week. Variation among species was statistically insignificant with Fpr of 0.13. The study by Kouawa *et al.* (2015) in contrast, recorded a relatively higher average shoot development rate of 2 shoots/day (14 shoots/week) for both species.

SV was recognised with the highest rate of leaf development at 44 ± 67 leaves/week and was followed by BV with an appreciable rate of 17 ± 8 leaves/week. A relatively lower rates of 6 ± 4 and 4 ± 5 leaves/week were however recorded for TL and BV respectively. Variation among species was statistically insignificant with Fpr of 0.06 yet SV, expressed considerable level of statistical difference in relation to CV and TL, taking into accounts the LSD of 36 (Table 3).

Kengne *et al.* (2014), similarly noted no significant difference ($P > 0.05$) in plant density, plant stem height and diameter (between different hydraulic loads of faecal sludge) for *Echinochloa pyramidalis*. The increase of the growth parameters was however, attributed to factors such as adequate moisture and nutrients which are mineralized and rendered bio-available for plants.

CONCLUSIONS

Despite the various levels of variability exhibited by species growth parameters, a generalised weekly growth was observed for all the species. Even though the weekly variation among species

were statistically insignificant, *Setaria verticillata* L. can be said to have enhanced adaptation to wastewater acclimatisation after recording the highest rate for both shoot and leaf development. The results generally indicate satisfactory reed potentials with wastewater acclimatisation and with potentials for faecal sludge load increment.

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