PURIFICATION OF INDUSTRIAL WASTEWATER WITH VETIVER GRASSES (VETIVERIA ZIZANIOIDES): THE CASE OF FOOD AND BEVERAGES WASTEWATER IN GHANA

Samuel Yeboah
Presbyterian University College

Allotey Albert
CSIR - Council for Scientific and Industrial Research - Ghana

PURIFICATION OF INDUSTRIAL WASTEWATER WITH VETIVER GRASSES (*VETIVERIA ZIZANIOIDES*): THE CASE OF FOOD AND BEVERAGES WASTEWATER IN GHANA

Yeboah, Samuel Akpah
Presbyterian University College, Ghana
GHANA

Allotey, Albert Nii Moe
Center for Scientific and Industrial Research,
Institute for Scientific and Technological Information, Accra
GHANA
&
Biney, Emmanuel
Pinora Ghana Limited, Asamankese
GHANA

ABSTRACT

The study focused on the morphological characteristics of the vetiver grass (*vetiveria zizanioides*), and its effectiveness in purifying industrial wastewater before being discharged into the external environment. For this study, vetiver grass was employed as a phytoremediation plant and grown hydroponically on three (3) different samples of industrial wastewater from three (3) selected Food and Beverages industries in the Eastern Region of Ghana. The results indicated that vetiver grass grown in Biogas effluent experienced the best growth where all 5 tillers developed; followed by vetiver grown in Pinora effluent sample, where two (2) tillers developed, and finally, the vetiver grown in Palm Oil Mill effluent experienced the worst growth. The physico-chemical analysis indicated that Biogas effluent experienced the highest removal rate of contaminants, followed by effluent from Pinora Ltd whereas effluent from from Oil Palm industry experienced a low removal efficiency of contaminant.

Keywords: Wastewater, phytoremediation, purification, vetiver grass (vetiveria zizanioides), hydroponically.

INTRODUCTION

Several plants have been adopted and used for various phytoremediation purposes. According to Chomchalow (2000), plants that have been tried and tested for various situations include poplar trees (used in the absorption of pesticides), indian mustard grass (accumulates selenium, sulfur, lead, chromium, cadmium, nickel zinc and copper), tomato (absorbs lead, zinc and cadmium) and bamboo to accumulate silica in its stalk and utilize it as crude protein in its leave. Others include sunflower for absorbing radioactive materials such as uranium, cesium and strontium made famous in the cleanup of post Chernobyl nuclear reactor disaster; duckweed for explosive waste, willows for hydrocarbon, and water hyacinth for uptake lead, copper, iron and mercury. While the vetiver grass has been identified to be very effective plant for soil erosion and sediment control,water conservation, and for land stabilization and rehabilitation (Truong, 2000).

Since its development by the World Bank for soil and water conservation in India in the 1980s, the Vetiver System (VS), originally known as the Vetiver Grass Technology (VGT), has provided a low-cost, simple technology employing live vetiver plant for soil and water conservation and environmental protection (Truong, 2000). Studies by Chomchalow (2000); Truong (1999a); Truong and Baker (1997, 1998) have shown that the vertiver system is a very practical, inexpensive, low maintenance and very effective means of soil erosion and sediment control, water conservation, and land stabilization and rehabilitation. Being vegetative, it is environmentally friendly (Chomchalow, 2000). Thus, from its initial usage in the agricultural sector, the vetiver grass' scope of applications has been explored and greatly expanded after its unique characteristics have been determined. The grass has many unique characteristics and lends itself ideally to engineering and environmental protection functions (Chomchalow, 2000).

Further studies by Cull *et.al*., (2002); Chomchalow (2000); Truong (1999a); Truong and Baker (1997, 1998); Pinthong *et al*. (1998) and Sripen *et al*. (1996) have proven that while the grass's application still plays a vital role in agricultural lands, vetiver's unique morphological, physiological and ecological characteristics, including its tolerance to highly adverse conditions, has played a key role in the area of environmental protection and land rehabilitation. Moreover, these grasses are tolerant to adverse conditions such as acidity, manganese and aluminum; salinity and sodicity; and, heavy metals like arsenic, cadmium, copper, chromium, lead, mercury, nickel, selenium and zinc (Chomchalow, 2000).

Bollag *et al.*, (1994) and Pradhan *et al.*, (1998) have proven that phytoremediation techniques for the treatment of different types of industrial wastewater are cost effective and efficient as compared to the traditional Industrial Wastewater Treatment Methods (WWTM). The latter, according to Tchobanoglous (2003), involve collection of wastewater in a central, segregated location called the (Wastewater Treatment Plant) and are subject to various treatment processes.These traditional wastewater treatment methods, which consist of the application of known technologies to improve and upgrade the quality of a wastewater, are very expensive (Pradhan *et al.*, 1998; Breaux *et al*., 1995 and Rebhun *et al*., 1990).

The attractiveness of phytoremediation, therefore lies in its seemingly simple principle of letting natural, living agents capable of functioning and reproducing independently and processing the pollutants out of the wastewater (Bollag *et al.*, 1994 and Pradhan *et al.*, 1998). Phytoremediation utilizes physical, chemical, and biological processes to remove, degrade, transform, or stabilize contaminants within soil and groundwater. According to Belz (1997), the plant takes the pollutant through the roots and stores in the plant (phytoextraction), volatized by the plant (phytovolatization), metabolized by the plant (phytodegradation), or any combination of these. In many cases, the vertiver plants help clean up many kinds of pollutants including metals, pesticides, explosives, oils and organic contaminants which are completely destroyed or converted to carbon dioxide (CO_2) and water (H_2O), rather than simply immobilized or stored (US EPA, 2012). They do this by releasing exudates and enzymes that stimulate bacteria and fungi to breakdown the pollutants and also enhance the biochemical transformation of the pollutants. (US EPA, 2012)

According to U.S. EPA (2000b), six phytoremediation mechanisms have been identified by which plants can affect contaminant mass in soil, sediments, and water. These include phytoextraction, phytovolatilization, phytodegradation, rhizodegradation, rhizofiltration and phytostabilization. Although these mecahanisms may have some similarities or overlap, each of them has an effect on the volume, mobility, or toxicity of contaminants, as the application of phytoremediation is intended to do. It has also been shown that implementing phytoremediation may result in a cost savings of 50 to 80 percent over traditional technologies (U.S. EPA, 2000b); provide habitat to animals, promote biodiversity, and help speed the restoration of ecosystems that were previously disrupted by human activity at a site (U.S. EPA, 2000b; Wilson, 2004). Finally, the process may promote better air or water quality in the vicinity of the site (Wilson, 2004).

The present study seeks to assess the efficiency of phytoremediation technology as an alternative method to addressing purification of wastewater from the food and beverages industry. Since phytoremediation technology has been identified by Kamathet *et.al*. (2004), Chomchalow (2000), and Truong and Baker (1998), to be best suited for tropical countries where plant growth occurs all year round. The presence of vetiver grass in the study area has permitted this experiment to be carried on at the premises of Pinora Ghana Limited, a juice processing company in Asamankese, Ghana.

STUDY AREA AND METHODOLOGY

The study area

Pinora Limited Ghana is a juice processing company situated in Asamankese, Small scale Oil Palm Mill at Asuokaw and Biogas Effluent from Fresh and Dry Company at Adeiso all companies located in the Eastern Region of Ghana (Figure 1). The experiment was conducted at the premises of Pinora Limited, Ghana, precisely at the Segregation Point area.

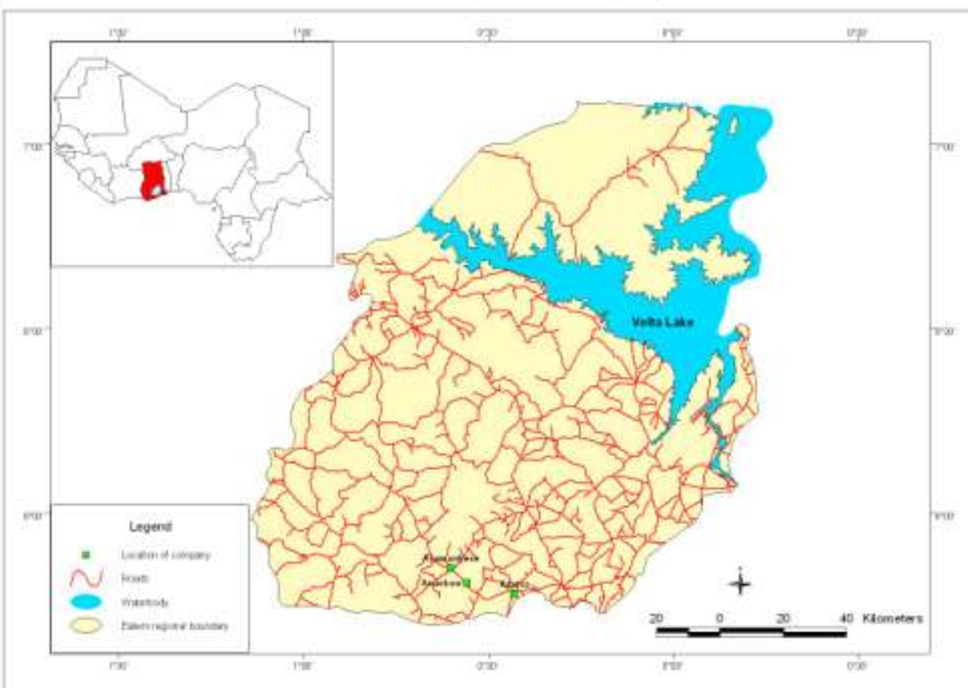

Figure 1: Eastern Region showing the Location of the Study Areas

The land is generally undulating with heights ranging between 60m and 460m above sea level, and being characterized by brimian and granitic rocks. The area lays within the West-Semi Equatorial climatic zone which experiences substantial amount of precipitation, characterized by a bi-modal rainy season with annual rainfall between 1,238mm and 1,660mm. The mojor rainy season occurs between March and July and minor from September to October every year. The rainfall is high enough to support all year round plant growth (District Assembly Environmental Sanitation and Strategic Action Plan (DESSAP, 2009).Vegetation in the area is characterized by tall trees with evergreen undergrowth. It also contains valuable and economic trees with scattered patches of secondary forest. (DESSAP, 2009)

MATERIALS AND METHODS

Two (2) methods were employed for this study: the first involved an experiment, which was conducted at the segregation point area of the premises of Pinora Limited, Ghana; and, the second involved a physico-chemical and bacteriological laboratory analysis.

Method 1: Hydroponic analysis

- Tillers of Vetiveria zizanioides (vetiver grass) were hydroponically grown on all three (3) samples of industrial wastewater supported by polypropylene as a floating platform in a 50L plastic capacity drum;
- The wastewater sample collected from Pinora limited was labeled W1, Small scale Oil Palm Mill Effluent was also labeled W2 (Asuokaw) and Biogas Effluent from Fresh and Dry company at Adeiso labeled W3;
- Five tillers of vetiver grass were grown on all three different samples of industrial wastewater;
- Before planting Vetiver tillers, the stem were pruned to about 20cm and root height determined as 10cm and equal volume determined; and,
- The wastewater with the hydroponic system were then labeled and samples taken before and after for analysis.

Using a well calibrated dip stick, the volume of each drum containing wastewater were determined and recorded after every 30 days for 120 days (4-months). Again, after every 30 days, plant height (shoot) and root height were measured and recorded using a measuring tape for a period of 120 days (4-months). Initial samples of wastewater (before treatment) and final samples of wastewater (after treatment) were collected from the three (3) different sources of industrial wastewater from the experimental grounds, using 500ml sterilized bottles which were labeled and placed in a chest containing chilled ice and sent to the Council for Scientific and Research Institute – Water Research Institute, Accra (CSRI-WRI) for analysis of inherent and final significant changes in their physicochemical and microbiological parameters.

Method II: Physico-chemical and microbiological analysis
Materials and methods

In all, three (3) samples of industrial wastewater which had been hydroponically treated were analyzed to determine Total Dissolved solids (TDS), Total Suspended Solids (TSS), turbidity,

ISSN 2313-7797

colour, and pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate, Ammonia, and Phosphate. Both TDS and TSS were measured using the gravimetric methods. TDS is the portion of total solids that pass through a standard filter paper. Samples were filtered and the filtrate evaporated on a water bath. The residue left after evaporation was dried to a constant weight in an oven. The increase in weight over that of the empty dish was the weight of the dissolved solids. TSS are solids retained by a filter 2.0 µm (or smaller) pore size under specific conditions. The residue was retained on the filter and dried to a constant weight at 105°C. The increase in weight of the filter represented the TSS. In addition, the Nephelometric method was used to determine the turbidity of the water changes. A 25ml measure of the water samples were put in measuring cylinders. The surfaces of the sample cells were carefully cleaned with tissue paper. The cells with their contents were placed into the instrument (turbidimeter) light cabinet and covered with light shields. The turbidity was then read from the screen of the turbidimeter. The method was repeated for W2 and W3. Visual Comparison Method was used to determine the colour. Nessler tube was filled to the 50 ml mark with the wastewater samples. The sample was placed in the right hand compartment of the Nesslerizer lighted cabinet. Distilled water was placed in the left hand compartment for reference. The colour disk was placed in the disk compartment and the light of the Nesslerizer was switched on. The disk was rotated until a colour match was obtained. The colour in Hazen units was read from the disk. If the colour exceeded 70 units, it was diluted.

The pH was measured using pH Meter and a Combination Electrode. The electrode was connected to the meter and the system was calibrated using pH 4 and 7 buffers. The buffer solution was brought to the same temperature as that of the samples. A beaker was then rinsed and filled with pH 7 buffer. The electrode was immersed and stirred twice. The stirring was ceased with the electrode suspending in the solution and waited for 1-2 minutes for a stable reading. The electrode was withdrawn and rinsed with de-ionized water and shook gently to remove water. The above process was repeated using a pH buffer 4, 9 or 10. 0 % slope was turned to and the reading noted. The electrode was withdrawn and rinsed with de-ionized water, and the pH calibration was checked. The electrode rinsed with de-ionized water, the pH of the sample was measured and the value recorded.

Dilution Method was used to determine the BOD. Wastewater samples collected were diluted with aerated distilled water and incubated at 20^{o}C for 5 days. The dissolved oxygen (DO) concentration was measured before and after incubation. The BOD was calculated from the difference between the initial and final dissolved oxygen. Closed Tube Reflux Method was used to determine the COD. Wstewater samples were placed in culture tubes and digestion solution added. Sulphuric acid reagent was carefully run down inside the vessels to form acid layers under the sample-digestion solution layer. The tubes were tightly capped and inverted several times to mix completely. Tubes were placed in block digesters preheated to 150^{0}C, and refluxed for 2 hours behind protective shields. They were cooled to room temperature in test tube racks. Culture tube caps were removed and small TFE-covered magnetic stirrer added, followed by 1 to 2 drops Ferroin indicator. Stirring was done rapidly while titrating with standard 0.1M FAS. The end point was sharp colour changes from blue green to reddish brown. In the same manner, a blank containing reagents and a volume of distilled water equal to that of the sample was refluxed and titrated.

The Ammonia-Nitrogen was measured by Direct Nesslerization. The samples were allowed to settle and 50 ml was pipetted in to conical flasks. Two (2) drops of Rochelle salt was added 5 drops forum diluted sample. It was well mixed and 2 ml of Nessler's reagent was added. A blank was prepared with 50 ml ammonia-free water and 5 drops of Rochelle salt and 2 ml Nessler's reagent. The samples were allowed to stand for 10 minutes for colour development. The absorbance of the sample was determined using Spectrophotometer-UV/VIST60by PG Instruments at a wavelength of 410 using a1 cm light cuvette. The Spectrophotometer was zeroed with the blank solution. The Stannous Chloride Method was used for Phosphate (PO4-P). One hundred (100) ml of samples free from colour and turbidity was taken and 0.05 ml (1drop) phenolphthalein indicator was added. Strong acid was added to discolourize the samples and diluted to 100 ml with distilled water and phenolphthalein indicator was added and discharged. Four (4.0) ml of Molybdate Reagent I and 0.5 ml (10drops) Stannous Chloride reagent I added with thoroughly mixing after each addition. The absorbance was measure data wavelength of 690 mn on the Spectrophotometer-UV/VIS T 60 by PG Instruments after 10 minutes but before 12 minutes. The spectrophotometer was zeroed with a blank solution (prepared with 100 ml of distilled water). Hydrazine Reduction method was used to determine the Nitrate–Nitrogen. Ten (10) ml of the wastewater samples were pipetted in to test tubes A 1.0 ml of 0.3 M NaOH was added to all the three (3) samples and mixed gently. A 1.0 ml of reducing mixture which was prepared by adding 20 ml copper sulphate ($CuS0_4$) working solution and 16ml hydrazine sulphate to 20 ml 0.3 MNaOH, was added and mixed gently. The mixture was heated at 60^oC for 10 minutes in a water bath and then cooled to room temperature. After which 1.0 ml of colour developing reagents was added. It was shaken to mix and the absorbance was read at 520 nm with the Spectrophotometer-UV/VIST 60 by PG Instruments.

Finally, Bacteriological analyses involved the determination of total and faecal coliforms and *Escherichia coli* (E-Coli) by membrane filtration method. Twenty seven (27 g) of the Hicrome Agaris was suspended in 1 litre distilled water. This was heated to boiling to dissolve the medium completely. It was then sterilized by auto-claving at 121ºC for15 minutes.

RESULTS AND DISCUSSION

The effectiveness of vetiver grass in reducing wastewater volume

The experiment investigated the effectiveness of Vetiver grass in wastewater volume reduction. The percentage volume consumed through photosynthetic and transpirational activities were monitored and recorded for every 30 days in each effluent sample employed during the 120 days hydroponic treatment system. Figure 2 demonstrates the trend in percentage consumption in each effluent sample for the 120 days hydroponic treatment system.

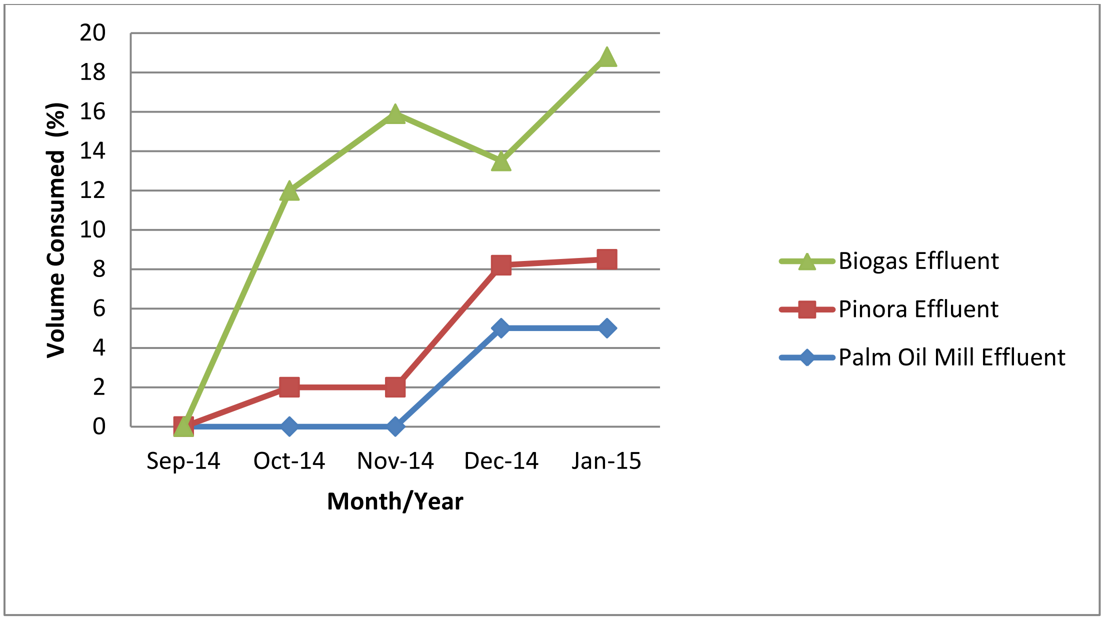

Figure 2: Percentage consumption rate of wastewater by vetiver grass after 120 days hydroponic treatment

The experiment revealed that for Pinora effluent, the wastewater volume employed at the start of the experiment was 50L, after the first 30 days which was in October, 2014 the volume reduced by 2% representing 1L of the total volume, whilst Biogas effluent reduced by 12% representing 6L of the total volume (50L) used. The volume for Pinora effluent sample reduced by 2% representing 1L where as Biogas effluent sample recorded 12% volume reduction representing 6L of its volume all in the 60^{th} day (November, 2014).

For Palm Oil Mill Effluent, there was no reduction in volume during the 30^{th} and the 60^{th} day of the experiment but recorded 5% reduction representing 2L of the total volume (40L) for the 90^{th} and 120^{th} day of the experiment respectively. Also, waste water volume for Pinora effluent sample reduced by 9% in both 90^{th} and 120^{th} day of the experiment which represented 4L of its total volume.

For Biogas effluent sample, 15.91% representing 7L of the total volume was recorded during the 60^{th} day of the experiment, whilst 5L and 6L were further lost all through photosynthetic and transpirational activities by vetiver grass in the 90^{th} and 120^{th} day of the experiment representing 13.51% and 18.75% respectively.

The impact of industrial wastewater on vetiver development

The average shoot and root heights of Vetiver development at 30, 60, 90 and 120 days after growing them in all three (3) different sources of industrial wastewater employed during the experiment are shown in Figure , 3, 4 and 5.

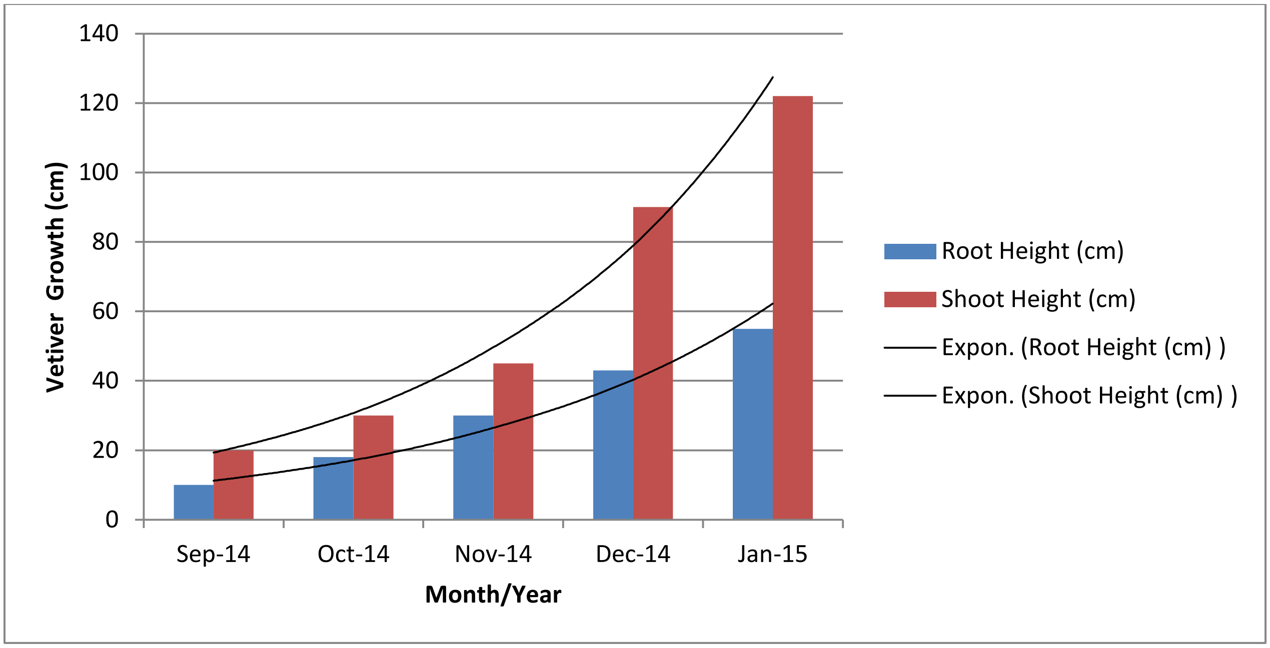

Figure 3: The growth rate of Vetiver grass for biogas effluent (W3) sample after 120 days hydroponic treatment

The average shoot and root heights at the start of the hydroponic treatment in the Biogas effluent sample were 20cm and 10cm respectively. At 30 days, the average shoot and root heights were 30cm and 18cm respectively. Also, at 60, 90 and 120 days, the average shoot heights were 45cm, 90cm and 122cm with corresponding average root heights development of 30cm, 43cm and 55cm.

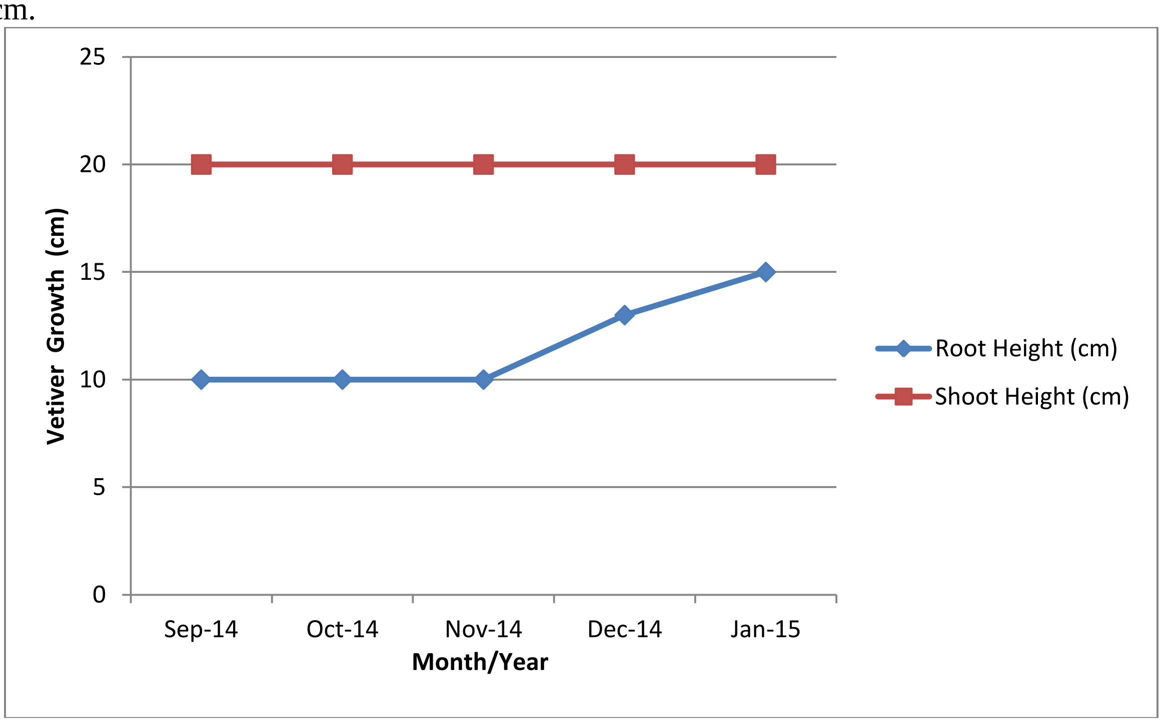

Figure 4: The growth rate of Vetiver grass for Palm oil Mill Effluent (W2) sample after 120 days hydroponic treatment

The average shoot and root height at the start of the hydroponic treatment in the Palm Oil Mill Effluent sample were 20cm and 10cm respectively. At 30, 60, 90 and 120 days, the average shoot height remained at 20cm throughout without any change in growth. The shoots were further observed not to have survived in the effluent sample because of its high organic content and the time frame of clean up for the treatment system. At 30 and 60 days, there was no incremental change in root development but recorded growth in the 90 and 120 days of the experiment as 13cm and 15cm respectively, it was then observed that, whiles its top growth (shoot) was killed, its underground growing point (roots) survived.

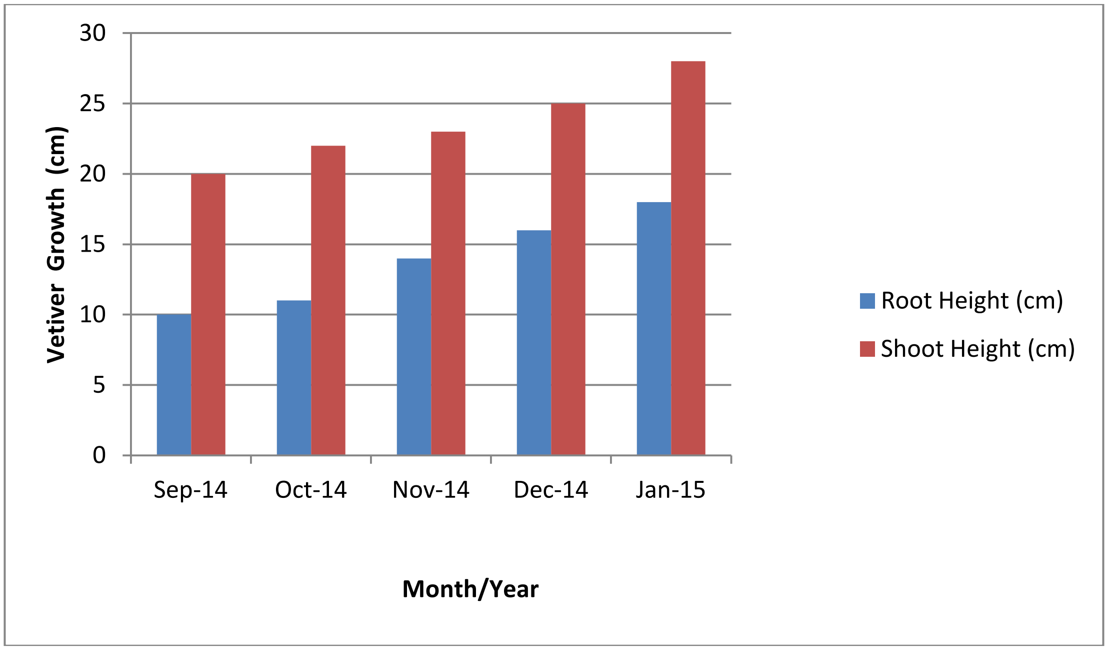

Figure 5: The growth rate of Vetiver grass for Pinora Effluent (W1) sample after 120 days hydroponic treatment

Finally, the average shoot and root height again at the start of the hydroponic treatment in the Pinora effluent sample were also 20cm and 10cm respectively. At 30, 60, 90 and 120 days, the average shoot heights were recorded as 22cm, 23cm, 25cm and 28cm with corresponding average root height development as 11cm, 14cm, 16cm and 18cm respectively.

Among the three (3) effluent samples employed for the hydroponic treatment in the purification of industrial wastewater, vetiver grass grown in Biogas effluent experienced the best growth where all 5 tillers developing. This was then followed by Vetiver grown in Pinora effluent sample, where two (2) tillers developed leaving the other three (3) tillers dead but with it underground growing points (roots) surviving. Finally, the vetiver grown in Palm Oil Mill Effluent experienced the worst growth.

Physico-Chemical and Bacteriological Analysis after 120 days Hydroponic Treatment
Changes in wastewater quality for Pinora Effluent (W_1)

In Table 1, the experiment recorded a decrease in TSS from 380mg/l to 70mg/l by 81.82% which is attributed to the Vetiver root system. TDS was also reduced from 845mg/l to 673mg/l by a percentage of 20.36. The Color of the effluent before was 750Hz which was above the Ghana Environmental Protection Agency's (EPA-Ghana) Effluent Standards permissible limit reduced exponentially to 50Hz by a change of 93.3%. Turbidity was also reduced from 151NTU to 54.6NTU by 63.8%. The pH recorded for both raw (7.12mg/l) and treated (7.02mg/l) effluents were within the limits of EPA industrial effluent standard. Elevated levels of BOD and COD were reduced to 302.0mg/l and 912mg/l by 93.76% and 85.51% respectively. The analysis of the samples revealed that the removal percentage of Phosphate was 84.57%, Ammonia-Nitrogen with 41.07% and Nitrate-Nitrogen the least, recorded as 9.99%. The absorption of these nutrients was expedited because vetiver roots had direct exposure to effluent which was in an agreement with the experiment conducted by Xia et al. (2000), Here, the vetiver grass grown had high affinity for Phosphate and aided in development.

Table 1: Physico-chemical Analysis of Results

Parameters (Units)	Measurements Raw (W1-R)	Treated (W1-T)	% Change	EPA Standard
TSS (mg/l)	385	70.0	81.82	50.0
TDS (mg/l)	845	673	20.36	1000
Color (HZ)	750	50	93.33	200
Turbidity (NTU)	151	54.6	63.84	75.0
P^H (PH Units)	7.12	7.02	1.40	6.0-9.0
BOD (mg/l)	4836	302.0	93.76	50.0
COD (mg/l)	6296	912	85.51	200
Nitrate- Nitrogen (mg/l)	0.721	0.649	9.99	50.0
Ammonia-Nitrogen (mg/l)	9.69	5.7	41.07	1.00
Phosphate (mg/l)	10.5	1.62	84.57	2.00

Changes in wastewater quality for Palm Oil Mill Effluent (W_2)

In Table 2, the results revealed high levels of physicochemical parameters in the raw palm oil mill effluent sample but did experience some considerable change after 120 days hydroponic treatment. The level of change in the wastewater quality was attributed to the development rate of Vetiver grass as well as the high organic content of the sample. The raw effluent showed TSS of 278,600mg/l and after treatment recorded 80,500mg/l with a percentage change of 71.11%.

Table 2: Physicochemical Analysis of Results

Parameters (Units)	Measurements Raw (W2-R)	Treated (W2-T)	% Change	EPA Standard
TSS (mg/l)	278,600	80,500	71.11	50.0
TDS (mg/l)	10,230	7,240	29.23	1000
Color (HZ)	2,000	1,500	25.00	200
Turbidity (NTU)	5,680	2,000	64.79	75.0
P^H (PH Units)	4.83	4.75	1.66	6.0-9.0
BOD (mg/l)	44,520	21,840	50.94	50.0
COD (mg/l)	128,911	115,596	10.33	200

Nitrate- Nitrogen (mg/l)	0.80	0.75	6.47	50.0
Ammonia-Nitrogen (mg/l)	20.40	12.2	40.20	1.00
Phosphate (mg/l)	12.60	10.2	19.05	2.00

Again, TDS was also reduced from 10,230mg/l to 7,240mg/l by a change of 29.23% The color of the effluent sample also saw a change of 25% from 2000Hz to 1,500Hz, Turbidity was also recorded to be 64.79% after 120 days hydroponic treatment. The pH before treatment was acidic (4.83) and remained acidic after treatment (4.75), Effluent sample before treatment had elevated levels of BOD (44,520mg/l) and Vetiver grass was able to reduce the value to 21,840mg/l by 50.94% change.

Again, COD levels before and after treatment were very high (from 128,911mg/l to 115, 596mg/l) with a small change of 10.23% Nitrate-Nitrogen concentration in the effluent sample before treatment (0.80mg/l) was within the EPA effluent threshold and after treatment the Vetiver grass was able to uptake 6.47%. The Vetiver grass had high affinity for Ammonia-Nitrogen with an absorption rate of 40.20% from 20.40mg/l to 12.2mg/l.

Changes in wastewater quality for Biogas Effluent (W_3)

Table 3 revealed exponential changes in wastewater quality for Biogas effluent after 120 days hydroponic treatment. TSS had an exponential change of 95.15% of 330mg/l in the raw effluent to 16.0mg/l after treatment and bringing it within the EPA effluent threshold value. TDS was also reduced from 2,560mg/l to 1,570mg/l by 38.67%. The color of the effluent sample before and after treatments were within the EPA effluent standard but recorded a change from 50 to 20 by a percentage change of 60%. Turbidity was 84.6NTU before treatment and was reduced to 10.4NTU after treatment by 87.71% and complied with the EPA effluent standard. The pH values before and after treatments were in compliance with the EPA effluent standard of 6.0-9.0. The BOD levels was reduced from 492mg/l in the raw effluent to 43.0mg/l in the treated effluent sample by an exponential change of 91.26% after 120days hydroponic treatment and bringing BOD value within the EPA effluent standard of 50.0mg/l.

Again, COD levels was also reduced from 1,952mg/l to 346mg/l by 82.27% change and bringing the value closer to the EPA effluent standard of 200mg/l Nitrate-Nitrogen was within the EPA effluent standard of 50mg/l but the Vetiver grass was able to uptake 99.18% from 0.122mg/l to 0.001mg/l.

The Vetiver grass grown absorbed and utilized the Ammonia-Nitrogen and Phosphate for growth and multiplication by 42.20% and 34.79% respectively. Ammonia-Nitrogen was reduced from 17.3mg/l to 10.0mg/l and Phosphate values from 11.9mg/l to 7.76mg/l. These nutrients remained outside EPA effluent standard after hydroponic treatment.

Table 3: Physicochemical Analysis of Results

Parameters (Units)	Measurements Raw (W3-R)	Treated (W3-T)	% Change	EPA Standard
TSS (mg/l)	330	16.0	95.15	50.0
TDS (mg/l)	2560	1570	38.67	1000
Color (HZ)	50.0	20.0	60.00	200
Turbidity (NTU)	84.6	10.4	87.71	75.0
P^H (PH Units)	7.08	7.16	-1.13	6.0-9.0
BOD (mg/l)	492	43.0	91.26	50.0
COD (mg/l)	1952	346	82.27	200
Nitrate- Nitrogen (mg/l)	0.122	0.001	99.18	50.0
Ammonia - Nitrogen (mg/l)	17.3	10.0	42.20	1.00
Phosphate (mg/l)	11.9	7.76	34.79	2.00

Changes in Bacteriological parameters for Pinora Effluent (W_1), Palm Oil Mill Effluent (W2) and Biogas Effluent (3)

As shown in Table 4, values of bacteriological parameters of all three wastewater samples employed during the 120 days hydroponic treatment system. Total Coliform for all three samples had significant changes after treatment, whereas Faecal Coliform and E.coli had an exponential increase after treatment rather than a reduction in microbial load. This condition was attributed to sample collection and storage time for analysis because of the assertion made by Truong and Hart (2001) in a research conducted where results showed that, vetiver was not only able to remove Nitrate and Phosphorus of over 90% from the effluent sample, but it went further to reduce algae and Faecal Coliform.

Table 4: Bacteriological Analysis of Results

Parameters (cfu/100ml)	Measurements W1 Raw	W1 Treated	W2 Raw	W2 Treated	W3 Raw	W3 Treated	EPA
Total Coliform	$45*10^3$	$25*10^3$	$41*10^4$	$29*10^4$	$48*10^4$	$38*10^4$	400
Faecal Coliform	$10*10^3$	$16*10^3$	$13*10^3$	$42*10^3$	$7*10^4$	$30*10^4$	10
E. coli	$5*10^3$	$7*10^3$	$4*10^3$	$18*10^3$	$2*10^4$	$13*10^4$	10

CONCLUSION

A challenging condition created by the influx of industries across the length and breadth of Ghana is the treatment and discharge of wastewater on to the external environment. All three (3) local industries (belonging to the food and beverage industry) selected had poor wastewater treatment plants or systems and their discharge of wastewater on to the external environment contain contaminants which can cause surface water and land pollution. After the application of phytoremediation utilizing vetiver grass, impressive results demonstrated the ability of the vetiver grass in improving wastewater quality and thereby reducing or eliminating the negative effects on the environment during wastewater discharge.

ISSN 2313-7797

The experiment therefore revealed that, the removal efficiency of contaminants like TSS, TDS, Turbidity, and BOD, COD and nutrients concentration varied among the three (3) industrial effluent samples employed. Their elevated levels were reduced drastically, bringing it within the EPA effluent standards.

ACKNOWLEDGEMENT

We wish to express our sincere thanks to Pinora Ghana Limited for making their premises available to us to undertake the hydroponic treatment. We our also grateful to Mr. Adu Ofori at the Council for Scientific and Industrial Research, Water Research Institute, Accra (CSRI-WRI) for his valuable services in the waste water samples analysis.

REFERENCES

Belz, K.E. (1997l) "Phytoremediation" Soil and Groundwater Pollution, Civil Engineering Department, Virginia Tech. CE 4594.

Bollag, J.M., Mertz, T., Otijen, L., (1994) Role of microorganisms in soil remediation. In: Anderson T.A, Coats J.R. eds. Bioremediation through rhizosphere technology. ACS. Symp. Ser.563. American Chemistry Society. York, PA, Maple Press. pp. 2-10.

Breaux, A., Farber, S., & Day, J. (1995) Using natural coastal wetlands systems for wastewater treatment: an economic benefit analysis. *Journal of Environmental Management*, *44*(3), 285-291.

Chomchalow, N. (ed.) 2000 Manual of the International Training Course on the Vetiver System, ORDPB, Bangkok, Thailand.

Cull, H.; Hunter, H.; Hunter, M.; and Truong, P.N.V. 2002 Application of VGT in offsite pollution control. II- Tolerance of vetiver grass towards high levels of herbicides under wetland conditions.Proc. ICV-2, pp.404-406. ORDPB, Bangkok

Kamathel, R.,Rentz, J. A., Schnoor, J. L. and Alvarez, P. J. J. (2004) Phytoremediation of hydrocarbon-contaminated soils: principles and applications. Department of Civiland Environmental Engineering, Seamans Center, University of Iowa, Iowa City, Iowa, U.S.A. – 52242.

Pithong, J., Impithuksa, S.,and Ramlee, A. (1998) The capability of vetiver hedgerows on The decontamination of agro chemical residues. Proc. ICV-1, pp. 91-98.ORDPB, Bangkok.

Pradhan, S.P., Conrad, J.R., Paterek, J.R., Srivastava, V.J., (1998) Potential of Phytoremediation for treatment PAHs in soil at MGP sites. Journal of Soil Contamination. 7: 467-480.

Rebhun, M., & Galil, N., Wastewater treatment technologies. In L. Zirm and J. Mayer (Ed). The Management of Hazardous Substances in the Environment. Elsevier Applied Science, London, 1990, pp. 85–102.

Sripen, S., Komkris, T., Techapinyawat, S., Chantawat, S., Masuthon, S., and Rungsuk, M. (1996) Growth potential of vetiver grass in relation to nutrients in wastewater of Changwat Phetchaburi. Paper presented at ICV-1. In: Abstracts of papers presented at ICV-1, p. 44. ORDPB, Bangkok.

Tchobanoglous, G., Burton, F.L., and Stensel, H.D. (2003) Wastewater Engineering

Treatment Disposal Reuse. Metcalf and Eddy, Inc. (4th ed.). McGraw-Hill Book Company.

Truong, P.N. and Baker, D. (1997) The role of vetiver grass in the rehabilitation of toxic and contaminated lands in Australia. International Vetiver Workshop, Fuzhou, China, Oct. 1997.

Truong, P.N. and Baker, D. (1998) Vetiver Grass System for Environmental Protection. PRVN Tech.Bull. No. 1998/1. ORDPB, Bangkok

Truong, P.N. and Hart, B. (2001)Vetiver System for Wastewater Treatment, Poster paper presented at the International Fresh Water Conference, Bonn in Germany in December 2001.

Truong, P.N. (2000) The Global Impact of Vetiver Grass Technology on the Environment. Proc. Second International Conference Thailand, January 2000.

Truong, P.N. (1999a) Vetiver Grass Technology for mine tailings rehabilitation. Proc. First Asia Pacific Conference on Ground and Water Bio-engineering for Erosion Control and Slope Stabilization. Manila, April, 1999.

United States Environmental Protection Agency (U.S. EPA , 2012) "*A Citizen's Guide to Phytoremediation*" EPA 542-F-12-003, www.epa.gov/superfund/sites. Accessed in December, 2014.

United States Environmental Protection Agency (U.S. EPA, 2000b) Introduction to Phytoremediation. EPA 600-R-99-107, Office of Research and Development.

Wilson, M.A. (2004) Ecosystem Services at Superfund Redevelopment Sites. Prepared for U.S EPA, Office of Solid Waste and Emergency Response, Policy Analysis and Regulatory Management Staff.

Xia, H.P., Liu S., Ao, H. (2000) Study on Purification and Uptake of Vetiver Grass to Garbage Leachate Proc. Second International Vetiver Conference. Thailand, January 2000.