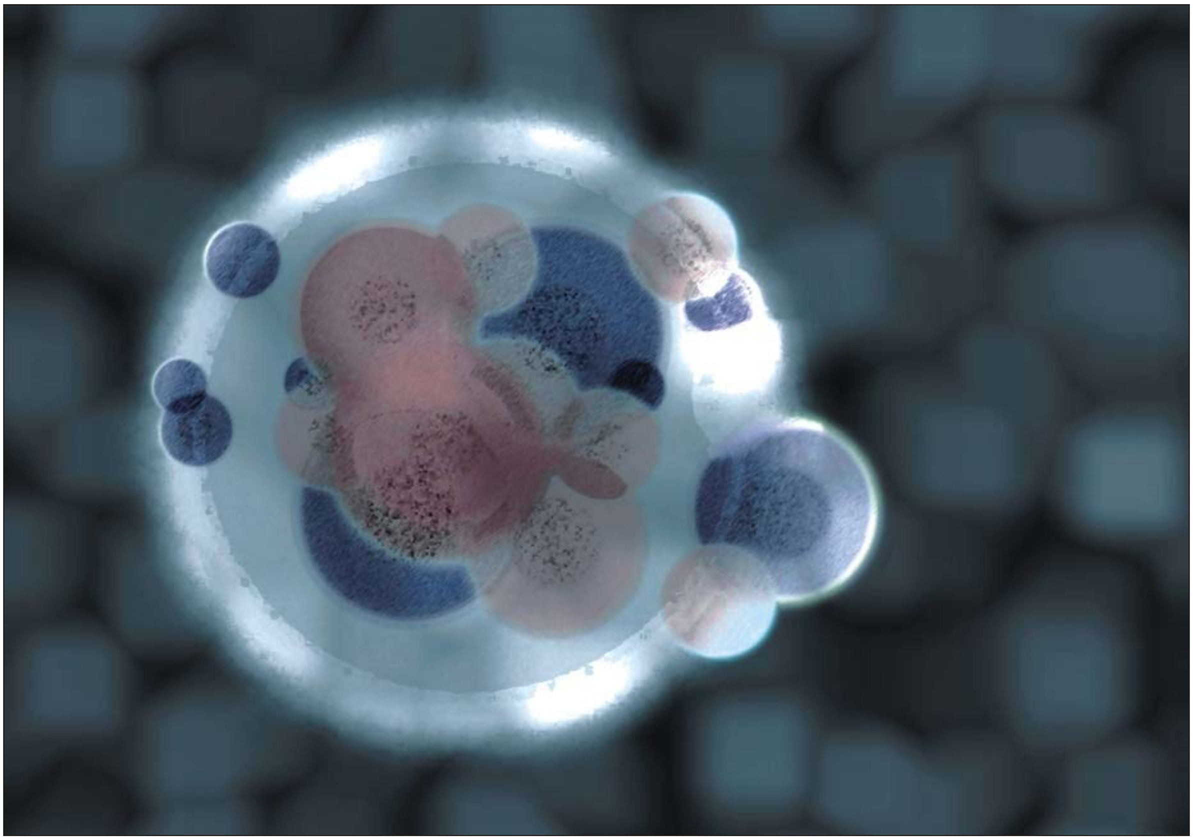

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Toxic Effects of Three Industrial Effluents on Growth and Development of *Vigna unguiculata* (L.) Walp (Cultivar it 84 E-124)

E.O. Oladele, P.G.C. Odeigah and T. Yahaya
Environmental Biology and Genetics Unit, Department of Cell Biology and Genetics,
Faculty of Science, University of Lagos, Akoka, Lagos, Nigeria

Abstract: The toxic effects of Paint, Battery and Textile effluents respectively on *Vigna unguiculata* (L.) Walp (Cultivar It 84 E-124) were evaluated in this study. Viable seeds were planted in 25, 50, 75% and neat (undiluted) effluents. Distilled water was used as control. The Physico-chemical characteristics of the effluents were analyzed. Heavy metals such as Zinc being 35.6 mg L^{-1} in Paint effluent, copper and lead were 10.5 mg L^{-1} in Battery effluent were found to be above Federal Environmental Protection Agency's limit suggesting toxic impact on the seedling. Leaf size, stem length and root length were observed to be responsive to the concentration gradient of the effluents. Dry weight declined with a positive response from mean value of 1.18 g for 25% Textile to 0.11 g for 25% Key paint. The test plant indicated high concentration of heavy metals in its biomass, for instance, 75% flash battery with highest fresh weight of 1.75 g except for textile effluent with 1.45 g. Textile effluent was also found to favour chlorophyll formation leading to photosynthesis while the other effluents were found not to be in favour of chlorophyll production. The mean total chlorophyll for control is 56.43 mg g^{-1}, Undiluted Textile being 51.45 mg g^{-1}, while Key paint has 9.11 mg g^{-1}. Howbeit, the severity of toxicity of the industrial effluents follow this trend; key paint higher than flash battery which is higher than textile at the different treatment concentrations of 25, 50, 75% and neat (undiluted). Suggesting that at very low concentration, *Vigna unguiculata* thrives better in textile effluents contaminated environment than battery and paint effluents. It is suggested that these parameters in cowpea may constitute methods of environmental monitoring.

Key words: Toxic, bio-concentration, environmental monitoring, bio-accumulation, bio-magnification

INTRODUCTION

The continuous increase in industries has become sources of pollution. These industries include battery manufacturing, iron and steel, plastics, chemicals, fertilizer, textile, food and beverages, breweries, pharmaceuticals, soap, petroleum and petrochemical, automobile, tannery, paper mill and cosmetics, tobacco and paint industries (Brown *et al*., 1996). Biochemical, biophysical and cellular processes; morphological and genetic adaptations enable living things to survive, Steevens *et al*. (1998) stated that a useful distinction exists between wastes which pose a potentially high risk to human health and those with much less hazards. Different activities of man have brought imbalances to the ecosystem. These activities mainly agricultural and industrial produce harmful effects to the environment resulting to pollution. According to FEPA in 1990, paints and resin wastes are usually generated from a variety of formulation and other tertiary chemical processes. They are typically combinations of solvents and polymeric materials including toxic metals. Many pollutants such as pesticides, oil, hydrocarbons, heavy metals as well as thermal and radioactive pollutants can get into aquatic environments through direct or indirect release from industries, agriculture and households (Fathi *et al*., 2008). The effects of oil in produce water as effluents from oil industry in soil include depression and inhibition of plant growth, by interfering with the soilwater-plant interrelationships (Mary and Dolor, 2007).

Heavy metals according to Ademoroti (1996), are defined as metals with density greater than 5 g cm^{-3}. These include: Copper, Zinc, Nickel, Cadmium and Lead. Heavy metals become pollutants when the quantity present in living organism is greater than the tolerable quantity for good functioning of the system. Unlike many organic pollutants that can be eliminated or reduced by chemical oxidation technique or microbial activity, heavy metals will not degrade (Cline and Reed, 1998). The heavy metals are passed through the food chain and are toxic as

Corresponding Author: E.O. Oladele, Environmental Biology and Genetics Unit, Department of Cell Biology and Genetics, Faculty of Science, University of Lagos, Akoka, Lagos, Nigeria

a result of bio-accumulation and bio-magnification. Heavy metals become pollutants when the quantity present in living orgarism is greater than the tolerable quantity for good functioning of the system. Unlike many organic pollutants that can be eliminated or reduced by chemical oxidation technique or microbial activity, heavy metals will not degrade (Cline and Reed, 1998). It should be noted that industrial effluents are not the sole source of contamination in the environment; they are possibly the most important single source contaminating or polluting aquatic environments. Serious concerns has been expressed over their discharge into the environment, being potentially persistent, toxic and accumulating in the biota (Oyewo, 1998). This study therefore was an attempt to assess the level of heavy metals in some industrial effluents and to investigate the effects of these effluents on the growth, germination and survival patterns of cultivar IT 84E-124 of *Vigna unguicalata* (L.) Walp.

MATERIALS AND METHODS

The study was conducted for 10 days in the Laboratory. Dry seeds of cultivar IT 84E-124 of *Vigna unguicalata* (L.) Walp with brown seed coat were collected from the International Institute of Tropical Agriculture (I.I.T.A), Ibadan. The industrial effluents were gotten from the main discharge points from three different locations: Woolen and Synthetic Textile Manufacturing Limited, Ikeja, Wahum Batteries, Ikeja and Golden Key paints, Akesan, Lagos. The effluents were collected In 5 L keg each at different times of the day to allow for increase in concentration and were stored in the refrigerator until analysis was done.

The physico-chemical analysis done includes: The pH, conductivity, alkalinity and total solids. The pH was measured using an Orion pH meter, A conductivity meter measured the conductivity and the alkalinity was determined by titration method while the total dissolved solids were determined using gravimetric analysis. The heavy metal analysis was also done using the Atomic Absorption Spectrophotometry Unicam 969 model (Table 1).

The viability test was done to ascertain the viability of the seeds before carrying out the study.

Macromorphometric studies/germination pattern: The following were observed and measured: germination rate, number of surviving seedlings, number of leaflets per plants, leaf colour changes, leaf size (cm^2), Stem and root length (cm), fresh and dry weight of seedling. Chlorophyll a and b were estimated spectrophotometrically, after acetone extraction of the pigments from fresh leaves.

Heavy metals analysis was done using the atomic absorption spectrophotometry Unicam 969 model.

Statistical analysis: All statistical analysis was carried out with the Microcal Origin software. All the experiments were conducted in triplicates. Comparison of data among treated and control plants were calculated using one way analysis of variance taking $p<0.05$ as significant level according to Dunnett's multiple comparison test. Graphical illustrations were also carried out to get vivid representation of the data obtained.

RESULTS AND DISCUSSION

The chemical constituents and heavy metal components of the three effluents were analyzed. The pH, Alkalinity, Zinc, Copper and Lead content of Battery effluent was found to be 9.3,920, 2.12, 10.5 and 10.5 mg L^{-1} respectively. These values were found to be far above the FEPA's statutory limit. The key paints and Textile effluent also had Alkalinity value of 150 mg L^{-1} with Zinc content of 35.6 and 1.45 mg L^{-1}, Copper content of 14.4 and 4.8 mg L^{-1}, respectively. These values were also found to be far above the FEPA's statutory limit. However, Lead was not detected in these two effluents (Table 1).

It is noted that there was a marked reduction in the mean fresh weight of battery and paint effluent with increased concentration as compared to the control. The control had 1.5 g of mean fresh weight while the plants treated with the neat (undiluted) effluents of battery and paints had a mean fresh weight of 0.95 g each. A significant difference ($p<0.05$) exists between the means of Fresh weight for the control and the plants exposed to the various concentrations of the effluents except for the textile which showed the non-significant difference ($p>0.05$) from the control. A significant difference ($p<0.05$) also exists between the means of dry weight for the control and the plants exposed to the various concentrations of the effluents except for the textile which showed the non-significant difference ($p>0.05$) from the control. The means of fresh and Dry weights also indicated a significant difference ($p<0.05$) between the control and the plants exposed to the each concentration of the effluents (Table 2).

From the values recorded in Table 3, there is marked reduction in the total chlorophyll content with increased concentration of the paint, battery effluents and undiluted Textile effluents showing a significant difference ($p<0.05$) from the control, while there was no significant difference ($p>0.05$) between the chlorophyll content for plants treated with textile effluents at lower concentrations and the control.

Table 1: Physico-chemical parameter of three industrial effluents

Parameter	Unit	Effluent-Source/Level detected: Golden key paints	Flash battery	Woolen and Synthetic textile	FEPA's limit
pH		7.4	*9.3	6.6	6-9
Colour		Blue	Brown	Light blue	NS
Conductivity	μsec cm^{-1}	780.0	528.0	296.0	NS
Alkalinity	mg L^{-1}	*150.0	*920.0	*150.0	20
Total dissolved solids	mg L^{-1}	390.0	264.0	148.0	2,000
Zinc	mg L^{-1}	*35.6	*2.12	*1.45	<1.0
Lead	mg L^{-1}	ND	*10.5	ND	<1.0
Copper	mg L^{-1}	*14.3	*10.5	*4.8	<1.0

ND: Not detected, NS: Not specified, * with concentrations above statutory limits

Table 2: The effects of industrial effluents on the fresh weight and dry weight (In grams)

Concentration	Mean fresh weight	Mean dry weight	Difference in Mean weight (weight loss)	p-values
Control	1.20±0.02**	0.15±0.02**	1.05	<0.0001*
25% Textile	1.30±0.02**	0.12±0.02**	1.18	<0.0001*
50% Textile	1.35±0.02**	0.15±0.02**	0.20	<0.0001*
75% Textile	1.40±0.02**	0.17±0.02**	1.23	<0.0001*
Neat (Undiluted) Textile	1.45±0.02**	0.20±0.02**	1.25	<0.0001*
25% Flash battery	1.48±0.02*	0.32±0.02*	1.16	<0.0001*
50% Flash battery	1.60±0.02*	0.25±0.02*	1.75	<0.0001*
75% Flash battery	1.75±0.02*	0.20±0.02*	1.55	<0.0001*
Neat (Undiluted) Flash battery	0.95±0.02*	0.10±0.02*	0.85	<0.0001*
25% Key paints	1.16±0.02*	1.05±0.02*	0.11	0.00253*
50% Key paints	1.10±0.02*	0.80±0.02*	0.30	0.06099**
75% Key paints	1.04±0.02*	0.55±0.02*	0.49	<0.0001*
Neat (Undiluted) Key paints	0.95±0.02*	0.30±0.02*	0.65	<0.0001*

Data were expressed as Mean±SD. When *p<0.05: Significant from control and When **p>0.05: Not significant from control

Table 3: The effect of industrial effluent on the Chlorophyll content of the plant, *Vigna unguiculata* (Cultivar It84e-124)

Concentration	Mean chlorophyll a	Mean chlorophyll b	Mean total chlorophyll	p-values
Control	20.01	36.42	56.43±0.2	1.0000**
25% Textile	22.00	36.50	58.50±0.2	0.2737**
50% Textile	20.22	34.63	54.85±0.2	0.3881**
75% Textile	18.00	34.70	52.70±0.2	0.0844**
Neat (Undiluted) Textile	16.70	34.75	51.45±0.02	0.1155*
25% Flash battery	25.00	25.80	50.80±0.2	0.0261*
50% Flash battery	21.23	26.00	47.27±0.2	0.0050*
75% Flash battery	18.50	26.50	45.00±0.2	0.0022*
Neat (Undiluted) Flash battery	12.47	27.00	39.55±0.2	0.0005*
25% Key paints	26.20	23.00	49.20±0.2	0.0048*
50% Key paints	24.54	21.46	46.00±0.2	0.0031*
75% Key paints	13.00	15.00	28.00±0.2	< 0.0001*
Neat (Undiluted) Key paints	1.14	7.97	9.11±0.2	< 0.0001*

Data were expressed as Mean±SD. When *p<0.05: Significant from control and When **p>0.05: Not significant from control

There was a marked reduction in the stem and root length of battery and paints effluents with increased effluent concentration, while the textile effluent showed minimal effect especially at the reduced concentration of 25%. The mean stem length for control was 9.63 cm, while the plants treated with undiluted battery and paint effluents had a mean stem length of 4.02 and 3.61 cm, respectively. The mean root length for control was 6.15 cm, while the plants treated with undiluted battery and paint effluents had a mean root length of 3.34 and 3.24 cm, respectively. A significant difference ($p<0.05$) exists between the means of stem length and root length for the control and the plants exposed to the various concentrations of the battery and paint effluents except for textile effluents with no significant difference ($p>0.05$) (Fig. 1, 2).

The seeds were found to have high percentage viability of 71.7%. It was observed that with increase in concentration, germination reduced for the treated seeds except for the control with expected increase in germination. However, germination was found to be very low with seeds treated with paint effluents compared to other effluents used in the study. The low rate in germination was probably due to toxicity resulting from effluent contamination around the seeds. This agrees with the findings of Dutta and Biossyna (1997) that worked on the effect of paper mill effluent on germination of rice seed and growth behavior of its seedlings and discovered that

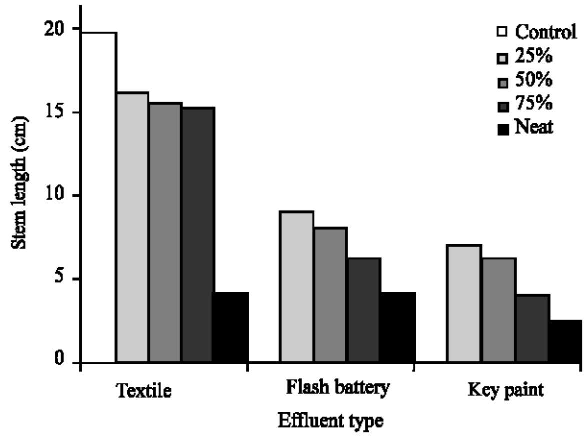

Fig. 1: Comparison of stem length of plant, *Vigna unguiculata* treated with three Industrial effluents by the tenth day

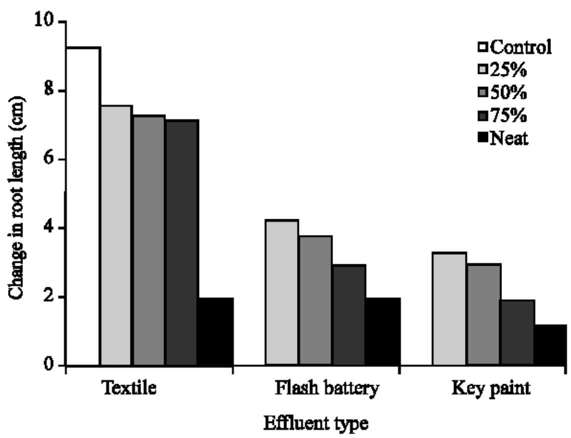

Fig. 2: Comparison of root length of plant, *Vigna unguiculata* treated with three Industrial effluents by the tenth day

effluents particularly at higher concentration inhibit germination. Rajni and Chauchan (1996) discovered in their investigation that the effect of tannery effluent on seed values of *Hordeum vulgaris* L. showed that the effluents caused a significant reduction in germination percentage. Ogunwenmo *et al.* (2010) also found out that paints effluents generally inhibited the germination of Leafy vegetables-*Amaranthus hybridus* and *C. argentea*. Germination rate of *Vigna unguiculata* treated with Textile effluents however found to be close to control at lower concentrations conforms to the findings of Nawaz *et al.* (2006) that Textile mill effluents supported the germination of *Cicer arientum*.

The percentage of surviving seedlings decreased with increase in treatment concentration. The number of leaflets per plants with increase in treatment concentration was not affected. Treated seeds were found with yellow leaves with increase in the number of days and treatment concentration. The treated plants were also found to experience a decrease in stem and root length with increase in concentration. The decrease in stem length is in agreement with the findings of Ramasubramaniam *et al.* (1993) who discovered that seedling length of *Phaseolus mungo* grown in sand culture decreased with an increase in effluents concentration obtained from match dye industries. The reduction in stem growth was more pronounced in the seedlings treated with neat effluents from key paints. This may be due to heavy metal poisoning, as a result of high concentration of heavy metals like lead and zinc in the effluents (Table 1). The present result conforms to the findings of Zeid and Abou El Ghate (2007). Ademoroti (1996) had discovered that lead concentrates more in the stem of *Abelmoschus esculentus* (Okro) than at the tips. The eventual death of seedlings treated with neat effluents from key paints may be due to the high concentration of zinc in the effluent, which was found to be above the FEPA's statutory limit (Table 1). Umebese and Onasanya (2007) also found out the inhibitory effect of undiluted minta effluents on the growth of *Vigna unguiculata.* However, seedlings treated with textile effluents did not experience shortening of roots due to low concentration of heavy metals and presence of nutrients in the effluents, as shown in Fig. 1 and 2. This agrees with the result cited by Odiete (1999), which confirms the presence of nutrients in the textile effluents. In addition, Heidari *et al.*(2005) reported that *Zea mays* is a Pb tolerant plant and that Pb metal ions accumulate mostly in their roots and shoots (Malkowski et al., 1996). Lead was found to be a major heavy metal constituent in paints effluents (Table 1). The leaf sizes were also discovered to have reduced with increase in treatment concentration of the different effluents. This is a direct consequence of the root and stem inhibition. Seedlings treated with 25, 50 and 75% concentration of textile effluents have their stem growth almost like that of control. This probably was due to nutrients supplied to the seedlings by dyestuff in the effluents which contain a significant level of sulphur which provided the necessary nutrients for growth as described by Oputa and Ojo (2001). The lower concentrations of Textile effluents favouring the stem and root length of *Vigna unguiculata* agreed with the findings of Nawaz *et al.* (2006) who discovered that Textile mill effluents supported the stem and root growth of *Cicer arientum.*

A decrease in fresh and dry weights was observed for plants treated with paint and battery effluents except for textile effluent which was seen competing with the control plants (Table 2). The chlorophyll content of treated plants was also found to be greatly reduced compared to the control (Table 3). The neat effluents of key paints however, had the least quantity of total chlorophyll content showing that the paint effluents did not favour (total) chlorophyll formation. This may be due to the presence of high content of lead in the paint effluent. A study by Ghani *et al.* (2010), revealed that the total chlorophyll content of Neelam variety of Maize decreased with increased lead toxicity. Also, this agrees with the study by Chaudhry and Qurat-ul-Ain (2003), that heavy metals disrupt the metabolic processes of living organism by inducing anatomical changes in primary leaves. These results are in agreement with that of Ramasubramaniam *et al.* (1993), who showed that there was a decrease in plant dry weight at high concentration of industrial effluent. Rajni and Chauchan (1996) also observed a significant reduction in the total biomass in almost all the varieties of *Hordeum vulgaris* L. treated with tannery effluent. Ramasubramaniam *et al.* (1993) in a similar study on *Phaseolus mungo* found out that a decrease in plant fresh and dry weight parallel a decrease in leaf pigment (chlorophyll a and b). This explains in this study, the change in colour of leaves from green to yellow and the consequent reduction in chlorophyll content except 25% dilution as the concentration of effluents increases thus affecting photosynthesis (sugar formation) (Table 3).

This work has revealed that Industrial effluents adversely affected germination, growth and development of *Vigna unguiculata* (L.) Walp (Cultivar It 84 E-124). The damages done to the plants at higher concentrations of the effluents are more severe than at lower concentrations. However, Industrial effluents like textile effluents can provide nutrition necessary for growth and yield at lower and appropriate concentration. Therefore, diluted textile effluents can be used as liquid fertilizer. This study also revealed the possibility of bioconcentration of heavy metals in plants and its attendant toxicity. Continued addition of these Industrial effluents can only lead to further deterioration of the ecosystem.

CONCLUSION AND RECOMMENDATION

This study has shown that industrial effluents contained some harmful pollutants such as heavy metals which are dangerous to life such as plants. It is suggested that further study on the genotoxicity of Industrial effluents on the same plant *Vigna unguiculata* (L.) Walp be embarked upon. The effects of these effluents can also be carried out on animals such as laboratory mice to know the likely effects on humans. Also, other industrial effluents apart from the ones used in this experiment can be used with varying concentration of the effluents for more accuracy. The various parameters in cowpea may constitute methods of Environmental Assessment.

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