Communication in Physical Sciences, 2022, 8(4): 581-589

Evaluation of Growth and Nutrient Profiles of *Phaseolus vulgaris* L. in Soil Treatment with Paint Waste Water

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Received: 18 July 2022/Accepted 22 September 2022/Published online: 30 September 2022

Abstract: *The effects of paint wastewater on the growth and nutrient contents of Phaseolus vulgaris* L *were examined. Paint wastewater used for this study was obtained from discarded used paint buckets around construction sites in Otuoke, Bayelsa State, Nigeria. The paint wastewater sample was adjusted to concentration levels of 20, 40, 60, 80 and 100% as contamination treatments alongside a control treatment (0%). Viable seeds of the test crop were sown in soil (2kg sandy loamy) per treatment. Growth parameters and mineral element content of the test crop were determined using standard procedures. This study showed that growth parameters such as shoot length, root length, leaf number, leaf length, leaf width, and petiole length of P. vulgaris seedlings significantly (P< 0.05) decreased with an increase in the concentration of paint wastewater with values relatively lower than that of the control. The calcium, sodium, potassium, magnesium, zinc, copper and iron contents in the leaves of P. vulgaris at 20%, 40%, 60%, 80% and 100% concentrations of paint wastewater significantly (P < 0.05) increased with an increase in the concentration of paint wastewater, however, the concentration of calcium was relatively lower than that of 0% concentration of paint wastewater, while those of sodium, potassium, magnesium, zinc, copper and iron were relatively lower than that of 0% concentration. Conversely, the phosphorus content at 20%, 40%, 60%, 80% and 100% concentrations of paint waste water decreased with an increase in the concentration of paint wastewater, but with the values recorded here relatively higher than that of 0% concentration of paint wastewater. Therefore, this result showed that paint wastewater had deleterious effects on the growth and nutrient contents of P. vulgaris. Therefore, paint waste water is not a good source of irrigation water for the test crop.*

Keywords: *Growth, nutrients, Phaseolus vulgaris, soil, paint wastewater*

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1.0 Introduction

Paints are used by industrial and residential facilities for manufacturers of cars, appliances, electronics, buildings and other products to protect and provide colour to their products (ACTenviro, 2022; Steward, 2019). Mass production and utilization of paints for coating facilities and appliances usually generate large quantities of waste paint, which may be disposed of either based on approved regulatory measures or indiscriminately into both terrestrial and aquatic environments (Poth, 2008; Jamal, 2017; Kopeliovich, 2014). It is important to note that these terrestrial and aquatic systems are habitats for vast varieties of living organisms as well as agricultural land

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under cultivation. Most effluents produced from industries and other anthropogenic activities in the developing and developed world are often discharged into water bodies, which are sources of irrigation for crops (Chidozie and Nwakanma, 2017; Chennakrishnan *et al*., 2008). Irregular disposal of waste materials leads to the introduction of pathogenic organisms, oxygen-demanding organic substances, plant nutrients that stimulate algal blooms, and inorganic and organic toxic substances, thus causing water pollution and degradation of soil conditions (Cornish *et al*., 1999). One of the greatest concerns to the farmers and conservationists is environmental pollution resulting from the discharge of toxic substances and untreated industrial effluents as well as indiscriminate disposal of wastewater (Mathuthu *et al*., 1997). The consequence of global industrialization include among others; the deterioration of water quality and the generation of various harmful wastes, effluents and other toxic by-products produced alongside the desired products (Etukudo *et al*., 2016; Turner *et al*., 1990). Indiscriminate disposal of industrial wastes and effluent discharges has led to pollution problems particularly in Nigeria and Africa in general (Uzoukwu *et al*., 2004). Wastewater is regarded as a deteriorated form of water, which contain waste materials from various sources such as domestic, industrial, agricultural and related sectors. In addition, rinsed and laundry waters involving residual acids, plating metals and toxic chemicals are all constituents of wastewater (Chidozie and Nwakanma, 2017; Husain *et al*., 2014). Other sources of wastewater include agricultural activities, which generate various organic matter and plant nutrients as well as considerable amounts of potentially harmful substances and heavy metals such as Fe, Cu, Zn, Mn, Cd, Cr, Pb, etc (Lokhande *et al*., 2011). Similarly, paint-related wastes include organic and inorganic substances with effluent constituting the most significant form in terms of its constituents of heavy metals (Bhalerao and Adeeko, 1981; Oladele *et al*., 2013).

In general, paints are made of finely ground solid colour called pigments which may be natural (iron oxides, chrome oxides), synthetic (phthalocyanines - coal tar derivatives) as well as organic and inorganic form; a liquid vehicle with typical diluents including organic solvents such as petroleum distillate, alcohols, ketones, esters, glycol ethers, and the like, while water is a common diluent and the main vehicle for water-based paints, which keeps the paints in suspension until applied; and synthetic or natural resins such as acrylics, polyurethanes, polyesters, melamine resins, epoxy, or oils that provide adhesive characteristic to the paints on the surface for a prolonged period; and commonly used bases (body) like white lead, zinc oxide, iron oxide and metallic powder (Al, Cu, Br), whose paints are usually named after such as Lead paint, Zinc paint, and Aluminum paint (Bently and Turner, 2000; Jamal, 2017;). The overall properties of the paints are influenced by the relative quantity of the constituents in the paints (Abagale *et al*., 2013), for instance, a typical paint is made of about 35% pigment and filler, and approximately 21% fill-forming and other constituents (ACTenviro 2022; Xu *et al*., 2015; ; ner, 1998). The common bean (*Phaseolus vulgaris* L.) belongs to the family Fabaceae, and is a legume commonly grown in sub-Saharan Africa as a source of food for humans and animals as well as a cash crop and soil conditioner (Masangwa *et al*., 2013). As a food source its seeds, leaves and pods are consumed by the teaming population, hence, it is highly cherished by the majority in terms of its availability for the common man (Høgh-Jensen *et al*., 2013). The seeds of common beans contain high protein, fibers, carbohydrates and other nutritional attributes, which make them a suitable food for healthy living and feeding the local population (Brougton *et al.*, 2015). Beans are among the leguminous species that have a symbiotic relationship with nodule-forming bacteria that fix nitrogen from the atmosphere into the soil, hence, the enrichment of soil with nitrogen for the surrounding plants (CIAT, 1986).

The Nigerian environment is characterized by environmental pollution arising from the indiscriminate disposal of wastewater from paint production and utilization (Magaji, 2012). The test crop, *P. vulgaris* is commonly grown locally on farmlands around residential areas and commercially around industrial cities where paint-related contamination may occur. It has been reported that chemicals used in paints are often toxic and may cause environmental contamination or health problems, while the volatile organic compounds (VOCs) found in paint are harmful to the environment as well as the people working around paint (Xu *et al*., 2015; Jamal, 2017; Kopeliovich, 2014). Therefore, it is due to these environmental threats that paints and paint-related products are considered to be hazardous wastes. It is on this note that treatment of wastewater before its discharge into the environment is desirable to avoid pollution, and industries are required by law to monitor their effluent to ensure compliance according to the established guidelines and standards for industrial emissions and effluent discharges as stated by the Federal Environmental Protection Agency (FEPA) now (FMEnv) (FEPA,1991). However, there is also the possibility of industrial wastewater utilization for irrigation purposes on cultivated land, especially in areas with water scarcity, as some wastewater has been widely used for the irrigation of crops under controlled conditions (Sela, 2021). This present study was carried out to assess the growth and nutrient profiles of *Phaseolus vulgaris* in soil treatment with paint wastewater.

2.0 Material and Methods

2.1 *Study area*

Otuoke terrestrial habitat in Ogbia Local Government Area of Bayelsa State, Nigeria was used as the study area. Otuoke is located at coordinates of 4°42′and 6°19′E. The inhabitants of the study area are mainly fishermen, farmers and traders. Generally, Bayelsa State is characterized by partially submerged habitats and aquatic terrains with completely secondary forest vegetation and a humid temperature averaging about 300 Celsius with a mean minimum monthly temperature ranging from 25^{o}C to 31 ^{o}C (Bayelsa State Media Team News, 2012).

2.2 *Collection of paint Wastewater*

Paint wastewater used for this study was obtained from discarded used paint buckets around a construction site in Otuoke, Bayelsa State, Nigeria. The paint wastewater sample was adjusted to concentration levels of 20, 40, 60, 80 and 100% as contamination treatments alongside a control treatment (0%).

2.3 *Collection of soil samples*

Soil samples were collected (0-20cm depth) from the Botanical garden of Federal University Otuoke and used for growth studies. The samples were collected using an acid-clean soil auger pack in a well labeled black polythene bag and taken to the experimental site for a germination experiment.

2.4 *Germination experiment*

Seeds of *Phaseolus vulgaris* used for this research were obtained from certified dealers in Yenagoa, Bayelsa State. Healthy seeds were sorted out and surface sterilized with 70% ethanol solution for 5 minutes and washed several times with sterile distilled water. Air-dried seeds (5 seeds) of the crop were sown in soil (2kg sandy loamy) per treatment. Each level of treatment was replicated three (3) times. A complete randomized block design was used as the research design. The experimental setup was maintained under light conditions (28 ± 1 ^{0}C) for 42 days (Etukudo *et al*., 2014).

2.5 *Growth Studies*

Growth parameters such as shoot length, root length, leaf number, leaf length, leaf width, and petiole length of the seedlings were measured as follows: The shoot length, leaf length, leaf width, petiole length and root length of the seedlings were measured with a meter rule and expressed in centimeters while the leaf number of the seedlings were determined by direct count (Udo *et al*., 2018).

2.6 *Mineral Analysis of Phaseolus vulgaris Seedlings*

Seedlings of *Phaseolus vulgaris* were first shadow-dried for 3 days, and macerated to small components. They were then oven-dried at 100^0C for 4 hours. They were crushed and ground to powder, then 2 grams each of the powders were weighed into Porcelain crucibles and placed in a muffle furnace and the furnace was set at 450 ^{0}C to ash. The ashing was done for 6 hours. The resulting ash was acid-digested in 15 ml of concentrated HNO_3 (Trioxonitric acid) on a hot plate. 20 ml of distilled water was then added to the crucible to dilute the acid in the crucible. The mixture was then filtered in a 100 ml volumetric flask and made up to the mark with distilled water. All the samples were then ready for AAS analysis. The AAS machine was then set up and the various elements (Ca, Na, K, Mg, P, Fe, Cu, and Zn) were analyzed at the specific wavelengths, lamps, currents, and gas mixtures (A.O.A.C. 1999).

2**.7** ***Statistical analysis***

Values of mean data obtained from the replicate readings were used to calculate standard error and data were subjected to analysis of variance (ANOVA) at 0.05 level of probability (Obi, 2002).

3.0 Results and Discussion

3.1 *Growth parameters of Phaseolus vulgaris in soil treated with paint wastewater*

The growth parameters of *Phaseolus vulgaris* in soil treated with paint wastewater are presented in Table 1. The plant height of *P. vulgaris* (16.55cm, 16.24, 16.18cm, 16.12 and 16.10cm) at 20, 40, 60, 80 and 100% concentrations, respectively, were significantly (P< 0.05) lower than that of 0% concentration (23.14cm). The leaf length of *P. vulgaris* (4.62, 4.55, 4.43, 4.14 and 4.12 cm) at 20%, 40%, 60%, 80% and 100% concentrations, respectively, were significantly (P< 0.05) lower than that of 0% concentration (6.21cm). The leaf width of *P. vulgaris* (2.94, 2.86, 2.56. 2.47 and 2.44 cm) at 20, 40, 60, 80 and 100% concentrations, respectively, were significantly (P< 0.05) lower than that of 0% concentration (3.90cm). The leaf number of *P. vulgaris* (15.32, 12.23, 12.17, 12.06 and 12.04) at 20, 40, 60, 80 and 100% concentrations, respectively, were significantly (P< 0.05) lower than that of 0% concentration (17.04 cm). The root length of *P. vulgaris* (27.88, 27.76, 27.43cm, 27.34cm and 26.55cm) at 20%, 40%, 60%, 80% and 100% concentrations, respectively, were significantly (P< 0.05) lower than that of 0% concentration (38.36cm). The petiole length of *P. vulgaris* (5.53, 5.45, 5.36, 5.24 and 4.82 cm) at 20%, 40, 60, 80 and 100% concentrations, respectively, were significantly (P< 0.05) lower than that of 0% concentration (7.12 cm) (Table1). Germination attributes such as germination rate and growth parameters such as plant heights, leaf areas, seed dry weights, root dry weights, number of seeds, and seed weights showed reduced responses in a higher level of paint effluent (Jolly *et al.*, 2008), and this was attributed to the negative response to the interaction of Ca with other nutrients in the soil, thus causing unavailability of certain nutrients for plant growth (Jolly *et al*., 2008; Agbede, 2009). Pollution of soil, particularly agricultural soils by heavy metals constitutes a serious environmental threat to plants and soil microorganisms (Udo *et al*., 2013; Magaji, 2012). Heavy metals contamination of the environment, particularly in elevated concentrations can lead to deleterious effects on the components of the ecosystem such as health risks to humans, reduction in plant growth and development, soil contamination and reduction in microbial activity (Gupta and Gupta, 1998; Osim *et al*., 2020; Udo *et al*., 2018). The presence of heavy metals in soil contaminated with paint-related wastes could support the reduction of the test crop growth parameters as observed in this study. Heavy metals have also been reported to accumulate in various organs of the body, thus leading to deleterious effects due to low biodegradable and long biological half-lives of heavy metals (Jarup, 2003, and Sathawara *et a l*., 2004).

Table 1. Growth parameters of *Phaseolus vulgaris* L. in soil treated with paint wastewater

Growth parameters	**The concentration of paint wastewater (%)**					
	0	20	40	60	80	100
Plant height (cm)	23.14±2.23	16.55±0.30	16.24±1.30	16.18±0.41	16.12±0.30	16.10±0.45
Leaf length (cm)	6.21±0.32	4.62±1.42	4.55±0.42	4.43±0.60	4.14±0.41	4.12±0.30
Leaf width(cm)	3.90±0.42	2.94±1.50	2.86±0.31	2.56±0.31	2.47±0.30	2.44±0.45
Leaf number	17.04±0.61	15.32±1.30	12.23±0.21	12.17±1.32	12.06±0.31	12.04±0.22
Root length (cm)	38.36±0.31	27.88±1.62	27.76±0.20	27.43±0.34	27.34±0.23	26.55±0.32
Petiole Length (cm)	7.12±0.22	5.52±0.34	5.45±0.38	5.36±0.20	5.24±0.34	4.82±0.28

**Mean ±standard error from three replicates

3.1 *Mineral elements in leaves of Phaseolus vulgaris in soil treated with pai nt wastewater*

The mineral elements in the leaves of *P. vulgar*is in soil treated with paint wastewater are presented in Table 2. The calcium, sodium, potassium, magnesium, zinc, copper and iron contents in the leaves of *P. vulgaris* at 20, 40, 60, 80 and 100% concentrations of paint wastewater significantly ($P < 0.05$) increased with an increase in the concentration of paint wastewater, however, the concentration of calcium was relatively lower than that of 0% concentration of paint wastewater, while those of sodium, potassium, magnesium, zinc, copper and iron were relatively lower than that of 0% concentration. Conversely, the phosphorus content at 20%, 40%, 60%, 80% and 100% concentrations of paint waste water decreased with an increase in the concentration of paint wastewater, but with the values recorded here were relatively higher than that of 0% concentration of paint wastewater (Table 2). A similar study was conducted by Jolly *et al*. (2008) that the pot soils without crop plants but irrigated with the same concentrations of paint effluent were found to show lower values for pH, EC and CEC and contain lower amounts of water-soluble salts, N, P, Na, K, Ca, Mg and Fe than the soils of pots with crop plants, indicating plant- nutrients interaction in the effluent-irrigated soils. Paint effluent has been reported to contain mostly biological degradable substances with an acidic pH as well as a small amount of soluble N, P, Na, Ca, Mg, Cl-1 and HCO3- (Hossain, 2004). The impacts of both organic and inorganic wastes including irrigation water sources on soil and plants have been reported to be dependent on the concentration as well as on the levels and nature of its chemical constituents (Etukudo and Egbe, 2017).

Dumpsites and wastewater usually contain contaminants such as heavy metals, acid mines, cyanides, radioactive substances and industrial chemicals that can p ose an environmental threat.

Soil is usually the most polluted part of the ec osystem around dumpsites, as well as the medium that easily receives wastewater with its attendant adverse impacts such as a threat to public health, production of methane through the decomposition of organic matters, and toxicity to plants (Lee and Jones, 2005; Osim *et al*., 2020). Although, the soil can receive and degrade wastes and pollutants of different forms, thus, acting as a purifying medium, and can filter out suspended matter, decompose organic matter by its microflora and precipitate out nutrients, however, if the quantity of pollutants is beyond the soil detoxification limit, soil microbial degradation activity is reduced considerably. This indicates the reason for the reduction in growth and development parameters of plants in polluted soil arising from deterioration in soil physicochemical properties (Jolly et al., 2008), as observed in this study.

Table 2. Mineral elements in leaves of *Phaseolus vulgaris* L. in soil treated with paint wastewater

C (mg/L)	Composition of paint wastewater					
	0	**20**	**40**	**60**	**80**	**100**
Calcium	3.05±1.11	1.52±0.41	1.61±1.14	1.85±0.54	2.11±0.23	2.26±0.28
Sodium	2.08±0.41	3.22±1.64	3.32±0.43	3.46±0.77	3.74±0.39	3.87±0.55
Potassium	3.92±0.64	4.34±1.43	4.37±0.22	4.43±0.23	4.49±0.35	5.08±0.87
Magnessium	2.83±0.06	3.45±1.82	3.54±0.34	3.66±1.90	3.74±0.84	3.93±0.14
Phosphorus	2.42±0.95	1.67±1.33	1.65±0.47	1.64±0.66	1.56±0.43	1.32±0.73
Zinc	0.07±0.02	0.19±0.04	0.21±0.06	0.23±0.02	0.24±0.05	0.29±0.04
Copper	0.05±0.01	0.13±0.01	0.18±0.05	0.19±0.04	0.21±0.02	0.24±0.03
Iron	0.03±0.06	0.12±0.08	0.13±0.02	0.15±0.05	0.18±0.03	0.26±0.02

****Mean ±standard error from three replicates**

4.0 Conclusion

This study showed that growth parameters such as shoot length, root length, leaf number, leaf length, leaf width, and petiole length of *P. vulgar*is seedlings decreased with an increase in the concentration of paint wastewater with values relatively lower than that of the control The calcium, sodium, potassium, magnesium, zinc, copper and iron contents in the leaves of *P. vulgaris* at 20%, 40%, 60%, 80% and 100% concentrations of paint wastewater significantly ($P < 0.05$) increased with increase in the concentration of paint wastewater, however, the of calcium content was relatively lower than that of 0% concentration of paint wastewater, while those of sodium, potassium, magnesium, zinc, copper and iron were relatively lower than that of 0% concentration. Conversely, the phosphorus content at 20%, 40%, 60%, 80% and 100% concentrations of paint waste water decreased with an increase in the concentration of paint wastewater, but with the values recorded here were relatively higher than that of 0% concentration of paint wastewater. Therefore, this result clearly shows that paint wastewater affected the growth and nutrient contents of *P. vulgaris* negatively, hence could pose environmental threats to the soil. It is also important to note that paint waste water is not suitable for irrigation of the test crop, hence, it is a matter of serious environmental concern for proper disposal of paint wastewater.

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Competing interests

The authors declared no conflict of interest. This work was carried out in collaboration among all authors.

Funding

There is no source of external funding

Authors' contributions:

Both authors contributed equally to the development of the manuscript.