

ORIGINAL RESEARCH ARTICLE

Effects of Industrial Coconut Oil Effluent on Vascular Tissue Structure of *Corchorus olitorius*Kwaya Vawanje Bitrus^{ID}, Murma Mari Ali^{ID} and Paul Adoyi Micheal^{ID}

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ABSTRACT

This study was carried out at different concentrations (0, 20, 40, 60, 80, and 100%) of industrial coconut oil effluent in the vascular tissues of *Corchorus olitorius*. The experiment was conducted in a screened house and arranged in a completely randomized block design in five replications. The results obtained on transverse sections of leaves, stems, and roots, and on the photochemical properties of the plant tissues irrigated with different concentrations of the ICE and control, were analysed at two-week intervals for four months. Generally, the comparative study of the effect of coconut oil industrial effluent on the leaves of *Corchorus olitorius* at different concentrations is shown. The epidermis was distorted in treatments with ICE concentrations of 60% or higher. However, other vital tissues, such as cambium, phloem, and pith, were present in all treatments. Moreover, a quantitative study showed that the different treatment concentrations affected the number of xylem cells. The distribution of tissues in the transverse section of *C. olitorius* leaves was summarized in this work. The xylem vessels of the 0% (control) treatment were 6–7 cells long, while those of treatments with 20% and 40% were 5–6 cells long; 60% and 80% had lower values, while the 100% treatment had no discernible xylem tissue. There was a dose-dependent decrease in vessel diameter (μ) with the highest number detected in 0% (control), followed by 40%, 20% and 60%, while 80% was the least; treatment 100% ICE had no record of vessel diameter.

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INTRODUCTION

Corchorus olitorius L. is a member of the family malvaceae. The species is referred to as mallow plant when grown for its edible leaves, and as a jute plant when cultivated for fibre used in rope production. The genus *Corchorus* contains about 50–60 species, with approximately 30 occurring in Africa (Guzzetti *et al.*, 2021). The valued parts of the plant are the fibre and leafy vegetable (Schippers, 2000). The species is an annual or short-lived perennial herb, which grows to about 2m tall. The fibred stems are well developed with abundant fibre in the phloem tissues; hence the species is grown as a fibre crop (Chweya and Eyzaguirre, 1999). The plant is an annual, much-branched herb, which grows about 2 m tall with glabrous stems, leaves (6–10 cm long and 3.5–5 cm broad), with pale yellow flowers and black trigonous seeds

Currently, due to population increase, food insecurity, unemployment, and economic crises, especially in developing countries, urban dwellers are increasingly turning to Africa indigenous vegetables AIVs because many lack sufficient funds to purchase exotic vegetables. *C. olitorius* is particularly important in Nigeria for food and nutrition security and income opportunities among smallholder farmers (Guzzetti *et al.*, 2021). The leaves

contain high levels of vitamin A, calcium, magnesium, iron, protein, and folate per 100 g edible portion.

However, the use of untreated industrial coconut oil effluent (ICE) for irrigation is growing threat to leafy vegetables. Industrial effluents contain heavy metals and emerging contaminants that cause phytotoxicity, anatomical distortion, and reduced nutritional quality of crops (Tiware *et al.* 2025). Studies on *C. olitorius* irrigated with textile dye effluents reported declines in morphological parameters and pigment content with increasing effluent concentration (Jamiu *et al.*, 2021). Similarly, industrial effluents have been shown to alter leaf anatomy, reduce stomatal and epidermal density by up to 40% and increase heavy metal accumulation in plants growing near industrial zones (Singh *et al.*, 2025). Heavy metals such as Cd, Pb, and Hg from effluent-irrigated soil accumulate in *C. olitorius* leaves at levels above the WHO/FAO permissible limits, posing a potential health risk (Ugwu *et al.*, 2025).

Despite the economic and nutritional importance of *C. olitorius* L., limited studies exist on the anatomical responses of *C. olitorius* L. to graded concentrations of ICE

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under south-eastern Nigeria conditions. Therefore, this study investigated the effects of ICE concentrations on the anatomy of the leaf, stem, and root vascular bundles of *C. olitorius* cultivated in south-eastern Nigeria.

MATERIALS AND METHODS

Study site and experimental materials

The study was carried out in the screen house of the Botanic Garden, Department of Plant Science and Biotechnology, University of Nigeria, Nsukka (UNN) of 6°51'56"N latitude and 7°24'22"E longitude. ICE was collected from a food factory in Nsukka urban. Capsules of *C. olitorius* L. were harvested from plants growing in fallowed home gardens in Danfodio Street, University of Nigeria, Nsukka. Poultry manure was bought from a poultry farm in the Department of Animal Science, University of Nigeria, Nsukka.

Physicochemical Analysis of Industrial Coconut Oil Effluent (ICE).

The pH was determined using a battery-operated pH meter (Hanna Model). The biochemical oxygen demand (BOD) was determined following Winkler's method as described by Latimer and Horvitz (2006). Chemical oxygen demand (COD) was determined by mixing 3.5 ml of sulphuric acid and 1.5 g of potassium dichromate (Carranzo, 2012). Total organic carbon was determined by titration of ferrous ammonium sulphate. Potassium, zinc, nitrogen, and copper were determined using the process described by Latimer and Horvitz (2006) and a spectrophotometer (Systronic 21D). The presence of mercury was determined using the mixture/solution of 0.002 M potassium iodide (AOAC, 2002). Lead was determined by the sodium sulphide method (AOAC, 2002). Cadmium was determined using xylenol orange indicator (AOAC, 2002).

Field Experiment

Twenty-eight (28) polypots (25 x 12 cm) filled with 10 kg of topsoil and poultry manure (2:1) were used in the nursery. Four weeks after germination, the seedlings were transplanted into 300 perforated polypots. The polypots, measuring 25x12 cm, were filled with the same medium as the nursery. The potted seedlings were divided into five batches of sixty polypots per batch. The five batches of potted seedlings were displayed in a screened house in order to avoid rain interference with the treatments. The first batch, the control, was irrigated with tap water only, while the second, third, fourth, fifth and sixth batches were irrigated with 100%, 80%, 60%, 40%, and 20% industrial coconut effluent, respectively. The experimental design was a Completely Randomized Block Design (CRBD). Each treatment was replicated five times, and each replication was assigned sixty polypots containing two seedlings per polypot.

Anatomical study

The anatomical studies of the stem, leaf and root were carried out in the Anatomy Laboratory of the Department of Plant Science and Biotechnology, University of Nigeria, <https://publications.umyu.edu.ng/scientifica>

Nsukka. Three mature plants from each treatment were carefully uprooted randomly at 6 weeks after irrigation. Sections were made at 1 cm from the root tip, 1 cm away from the base on the stems and the third leaf.

Procedure: The transverse sections of the stem, root and leaves and the transverse longitudinal and radial longitudinal sections of the stem and root, were made using a Reichert sledge Microtome. The sections were placed into Petri dishes containing 70% absolute alcohol to preserve the sections until they were needed for microscope studies.

Temporary Slide Preparation: The samples for study were mounted on 1-2 drops of iodine. Tissues stained blue-black, showing the presence of starch. Additionally, two drops of phloroglucinol and 2 drops of concentrated hydrochloric acid were added to confirm the presence of lignin. Glycerin was used as the mountant (Ojua *et al.*, 2020). The prepared sections were viewed under a Moticam light microscope at ×100 magnification. Photomicrographs of the sections were taken using a microscopic Moticam.

Data Analysis: Data obtained from the seedling growth parameters were subjected to analysis of variance (ANOVA) and significant means separated using Duncan's Multiple Range Test (DMTR). Other data were represented in Plates, Figures and Tables. Data obtained from Physicochemical analysis of the two water sources (Tap water and ICE) were compared to the accepted standard of the Federal Environmental Protection Agency (FEPA).

RESULTS

Chemical Analysis of Industrial Coconut oil Effluent

The results of chemical characteristics of industrial coconut oil effluent (ICE) had higher values of most of the water quality indicators (pH, total suspended solids, biochemical oxygen demand, chemical oxygen demand, nitrogen, calcium, magnesium, zinc, iron, cadmium, lead, chromium, mercury, nickel, copper and potassium) compared to the tap water. While the pH was lower than the Federal Environmental Protection Agency, other parameters were higher (Table 1).

Anatomical Study of *C. olitorius*

Generally, the comparative study of the effect of coconut oil industrial effluent on the leaves of *Corchorus olitorius* at different concentrations is shown in Plate 1a–f. The epidermis was distorted in treatments with ICE concentrations of 60% or higher. However, other vital tissues, such as cambium, phloem, and pith, were present in all treatments. Moreover, a quantitative study showed that the different treatment concentrations affected the number of xylem cells. Table 2 summaries the distribution of tissues in the transverse section of *C. olitorius* leaves. The xylem vessels of the 0% (control) treatment were 6 – 7 cells long, while those of treatments with 20% and 40% were 5 – 6 cells long; 60% and 80% had lower values, while Kwaya *et al.*, /USci, 5(2): 284 – 291, June 2026 285

the 100% treatment had no discernible xylem tissue (Table 2). There was a dose-dependent decrease in vessel diameter (μ) with the highest number detected in 0%

(control) followed by 40%, 20% and 60%, while 80% was the least; then treatment 100% ICE had no record of vessel diameter (Fig 1).

Table 1: Chemical Analysis of Industrial Coconut oil Effluent

Parameter	ICE	TW	FEPA Limit
pH	3.8	6.9	6.59
Total Suspended Solids (TSS) (mg/L)	500	NA	NA
Dissolved Oxygen (DO) (mg/L)	8.50	22.0	NA
Biochemical Oxygen Demand (BOD) (mg/L)	429.0	3.70	4.00
Chemical Oxygen Demand (COD) (mg/L)	520.30	40.20	120
Nitrogen (N) (mg/L)	0.29	0.001	0.10
Calcium (Ca) (mg/L)	26.50	15.00	0.20
Zinc (Zn) (mg/L)	6.50	0.20	2.00
Magnesium (Mg) (mg/L)	36.40	5.00	0.50
Iron (Fe) (mg/L)	2.60	0.25	4.00
Cadmium (Cd) (mg/L)	1.14	0.10	0.01
Chromium (Cr) (mg/L)	0.20	0.00	0.10
Lead (Pb) (mg/L)	4.36	0.00	5.00
Phosphate (PO ₄) (mg/L)	0.35	0.20	0.02
Mercury (Hg) (mg/L)	2.00	0.00	0.10
Nickel (Ni) (mg/L)	0.14	0.00	0.02
Copper (Cu) (mg/L)	8.20	0.05	0.20
Potassium (K) (mg/L)	4.63	0.45	0.02
Oil and Grease (mg/L)	0.04	NA	NA

Key: ICE= Industrial Coconut oil Effluent, TW= Tap Water, FEPA= Federal Environmental Protection Agency, NA= Not Available

Table 2: Comparisons of the tissues distribution in the transverse section of the leaves of the *Corchorus olitorius*

Tissue Component	Control (0%)	20%	40%	60%	80%	100%
Epidermis	Single-layered	Single-layered	Single-Layered	Single-layered with slightly distorted outline	Single-layered with distorted outline	Single-layered with distorted outline
Phloem	Present	Present	Present	Present	Present	Present
Cambium	Present	Present	Present	Present	Present	Present
Pith	Present	Present	Present	Present	Present	Present
Xylem vessels	6 -7 cells long	5 - 6 cells Long	5 - 6 cells long	3 - 4 cells long	1 - 2 cells long	-----

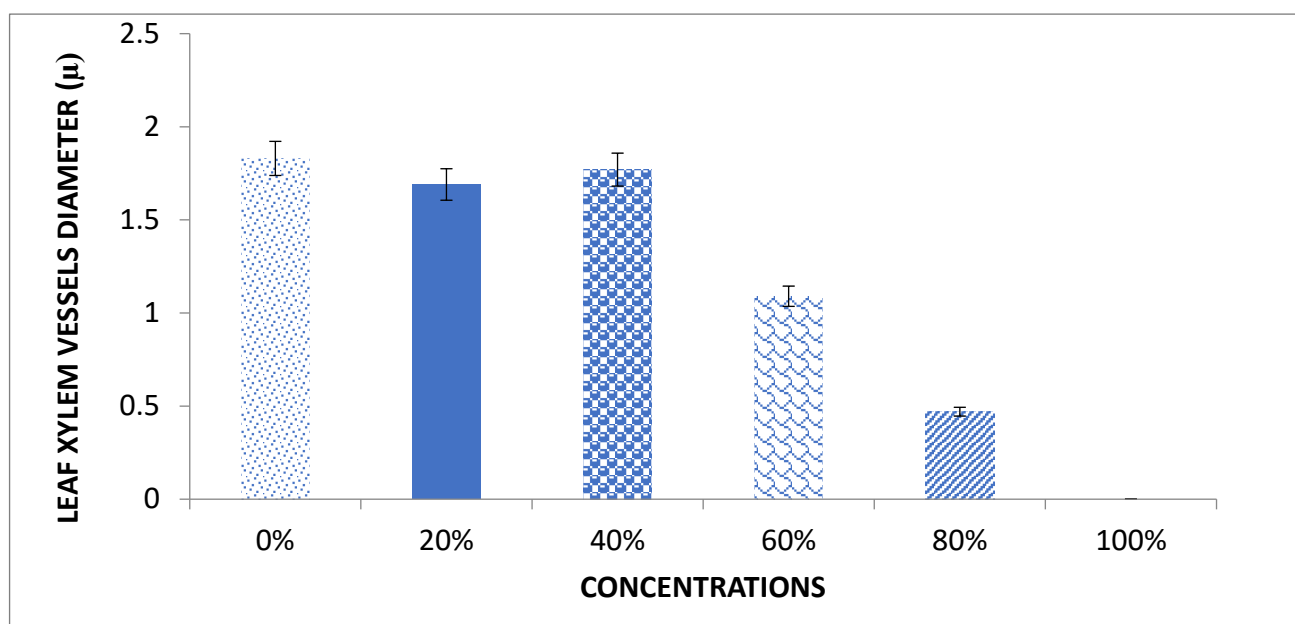


Fig 1: The effect of various concentration of industrial coconut oil effluent on leaf xylem vessels diameter (μ) of *Corchorus olitorius*

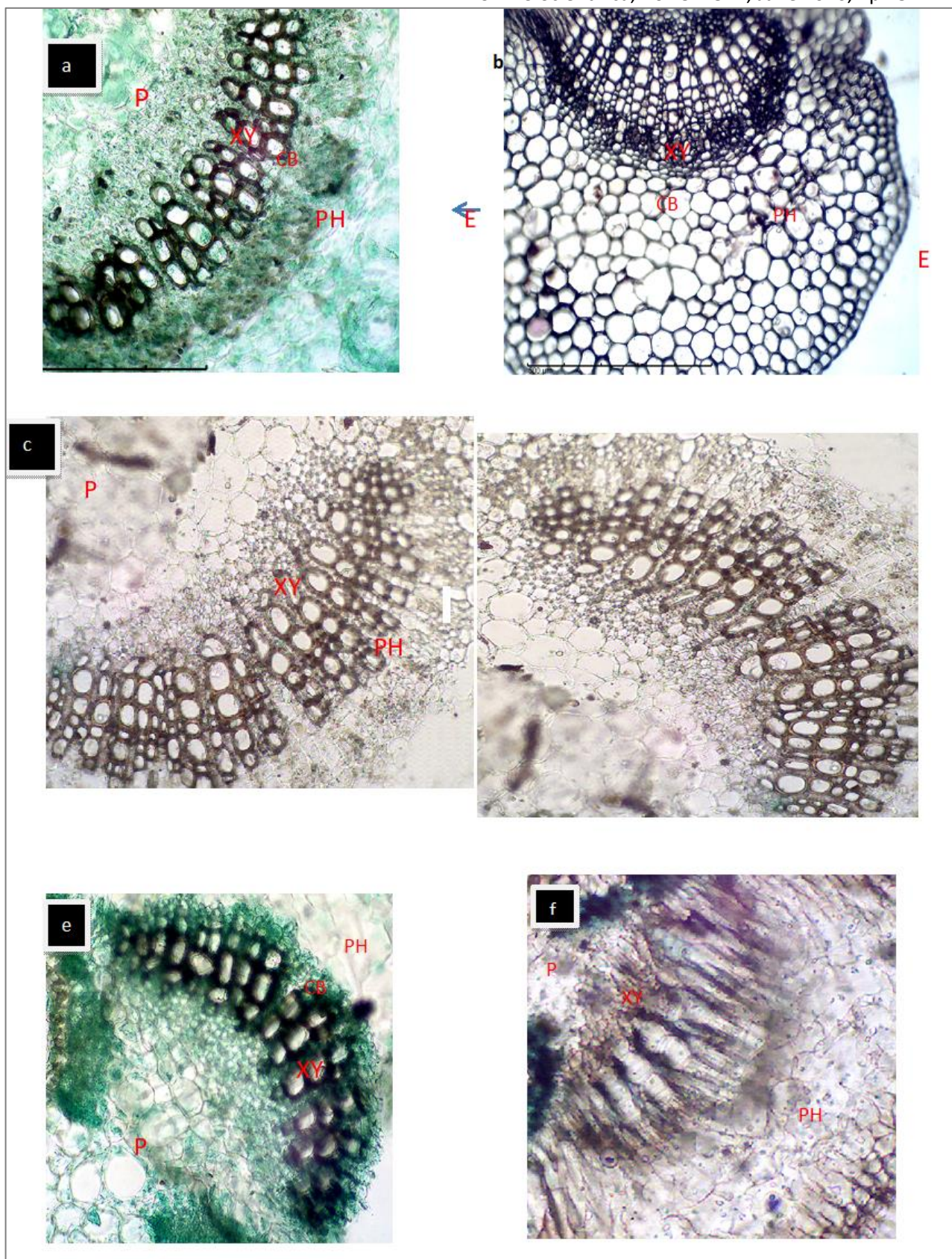


Plate 1: Transverse sections of leaves of *C. olitorius*: 0% (control) (a), 20% treatment (b), 40% treatment (c), 60% treatment (d), 80% treatment (e) and 100% treatment (f). P= Pith, XY= Xylem, PH= Phloem, E= Epidermis, CB= Cambium

The effect of industrial coconut oil effluent on the stem of *C. olitorius*

Changes in the anatomical structure of the stem of *C. olitorius* observed in the various effluent concentrations <https://publications.umyu.edu.ng/scientifica>

included distortion of vital tissues as shown in Plate 2. The stem epidermis was distorted at treatment 80% and 100% ICE and tissues such phloem, cambium and pith were present in all treatments (Table 3). Quantitative

study showed that the highest number of xylem vessels diameter was observed at 40% ICE treatment (0.76) and was significant at $p < 0.05$ followed by 60%, 0%, and 20%

ICE treatments while the lowest number of stem vessels diameter were obtained at 80% and 100% ICE treatments (Fig. 2).

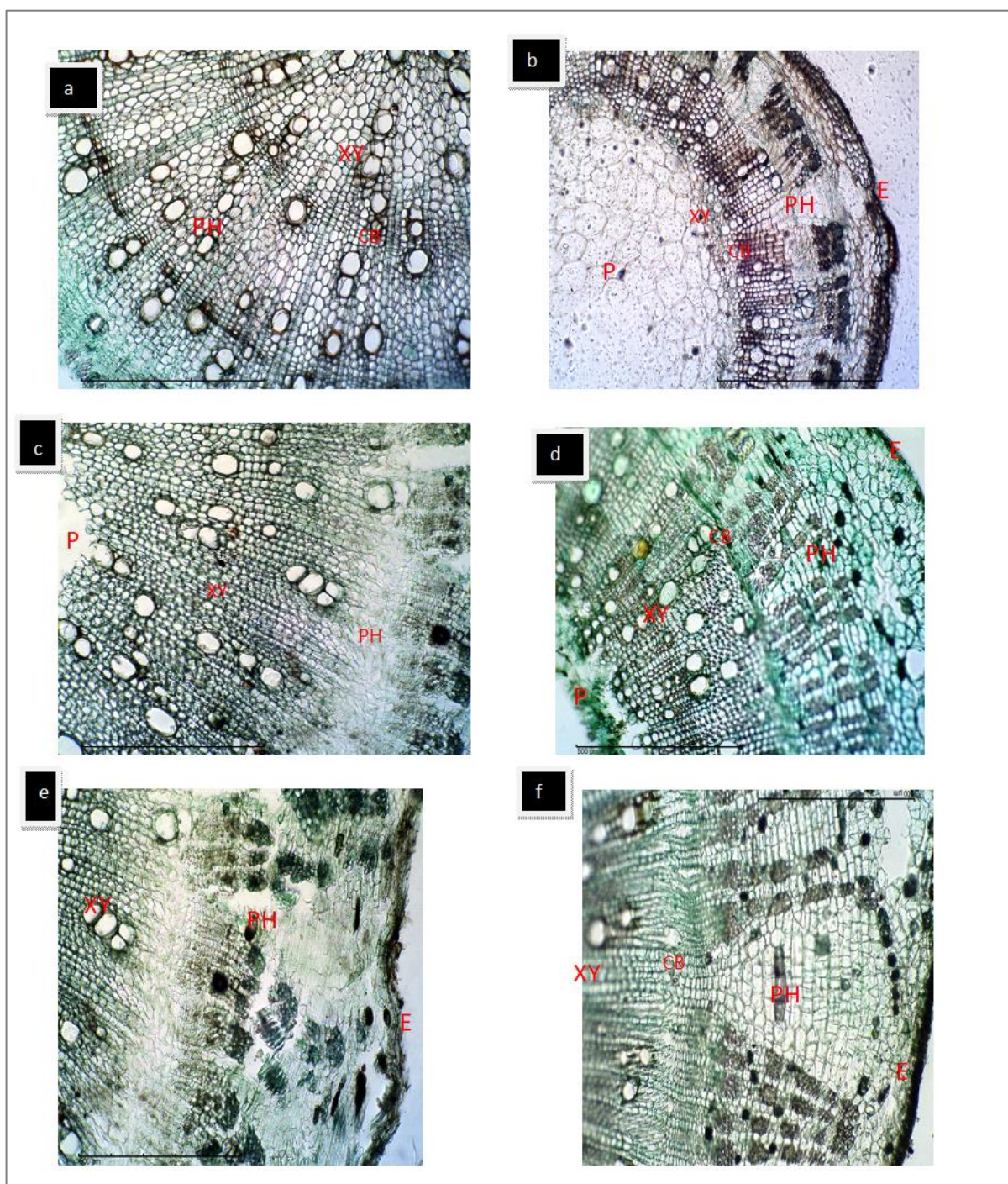


Plate 2: Transverse sections of stem of *C. olitorius*: 0% (control) (a), 20% treatment (b), 40% treatment (c), 60% treatment (d), 80% treatment (e) and 100% treatment (f). P= Pith, PH= Phloem, XY= Xylem, E= Epidermis, CB= Cambium

Table 3: Comparisons of the tissue distribution in the transverse section of the stem of the *Corchorus olitorius*

Tissue Component	Control (0%)	20%	40%	60%	80%	100%
Epidermis	Single-layered	Single-layered	Single-layered	Single-layered	Single-layered with distorted outline	Single-layered with distorted outline
Phloem	Present	Present	Present	Present	Present	Present
Cambium	Present	Present	Present	Present	Present	Present
Pith	Present	Present	Present	Present	Present	Present

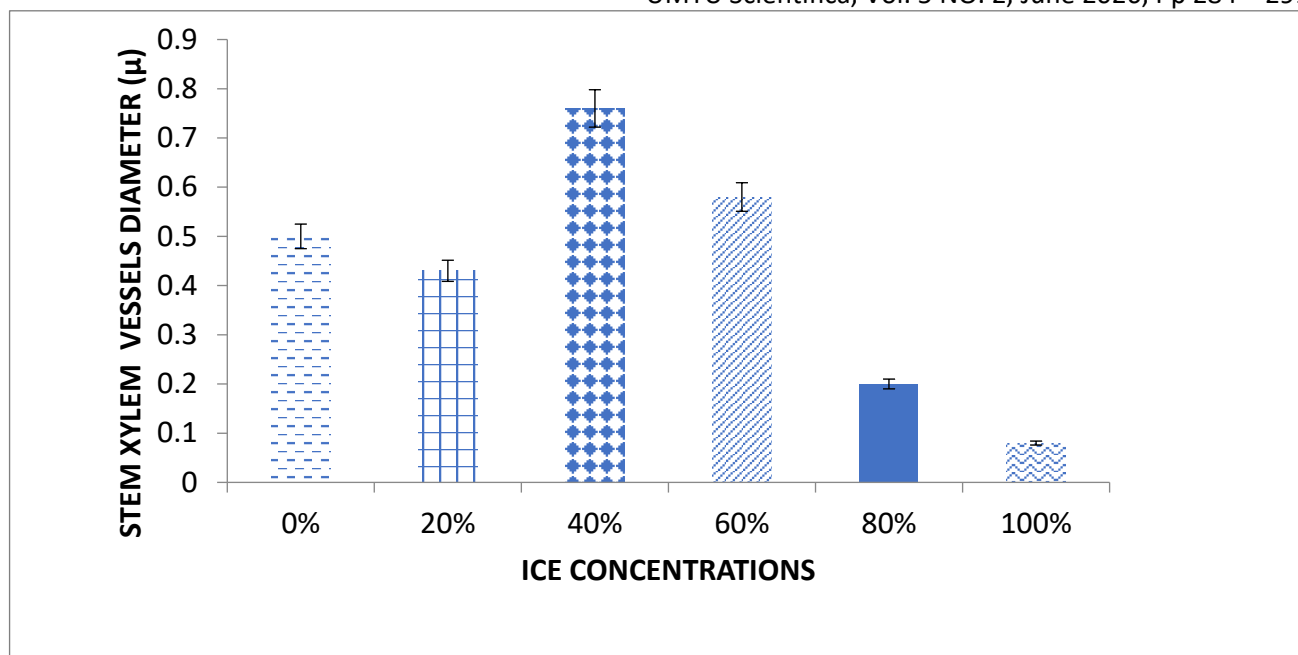


Fig 2: The effect of various concentrations of industrial coconut oil effluent on stem xylem vessels diameter (μ) of *Corchorus olitorius*

Table 4: Comparisons of the tissues distribution in the transverse section of the root of the *Corchorus olitorius*

Tissue Component	Control (0%)	20%	40%	60%	80%	100%
Epidermis	Single-layered	Single-layered	Single-layered	Single-layered	Single-layered with distorted outline	Single-layered with highly distorted outline
Phloem	present	present	present	present	present	Present
Cambium	Present	present	present	present	present	Present
Pith	present	present	present	present	present	-----

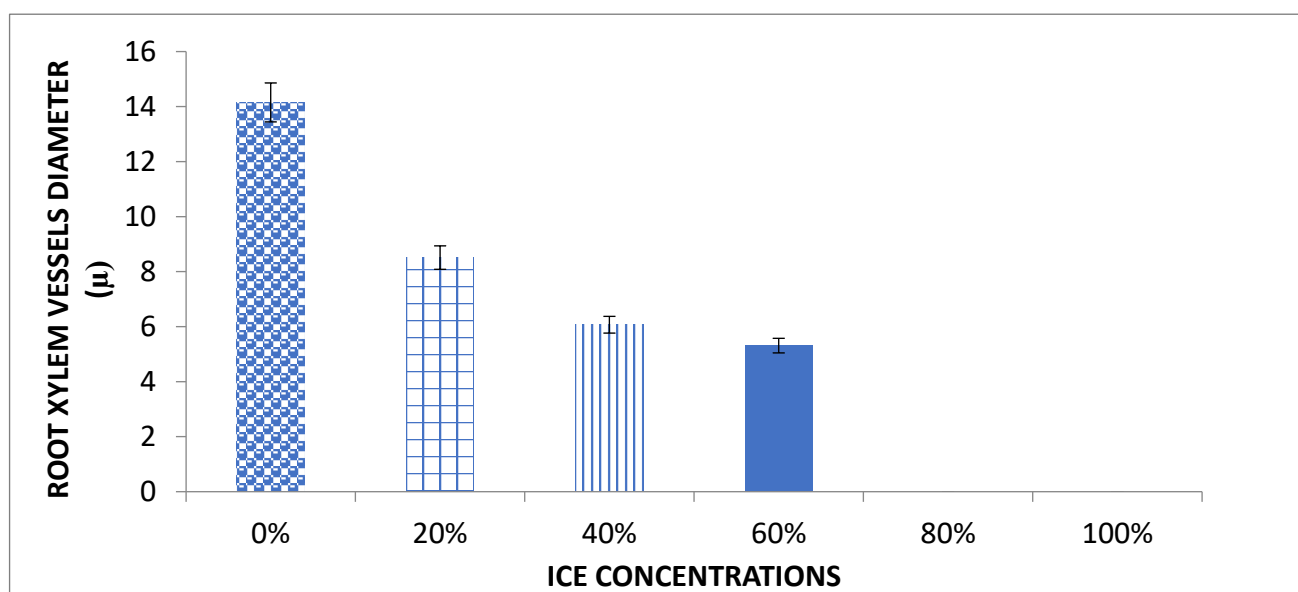


Fig 3: The effect of various concentrations of industrial coconut oil effluent on the root xylem vessels diameter (μ) of *Corchorus olitorius*

The effect of industrial coconut oil effluent on the root of *C. olitorius*

There were variations in the effects of various concentrations of ICE on the tissue components of the root of *C. olitorius* shown in Plate 3. The root epidermis was highly distorted at 100% ICE treatment. Phloem

cambiums were present in all treatments, but the pith was also present in all treatments except at 100% ICE (Table 4). The effects of the effluent concentrations on the root xylem vessels of *C. olitorius* were significant at $p < 0.05$. The root vessels showed a decrease in the number of root xylem vessels and in the diameter of root xylem vessels;

the 0% ICE (control) treatment had the highest (14.15), followed by the 20% ICE treatment, and the least was recorded in the 60% ICE treatment (5.31), with significant

differences. Furthermore, at 80% and 100% ICE were distorted; therefore, no xylem vessels were observed (Fig 3).

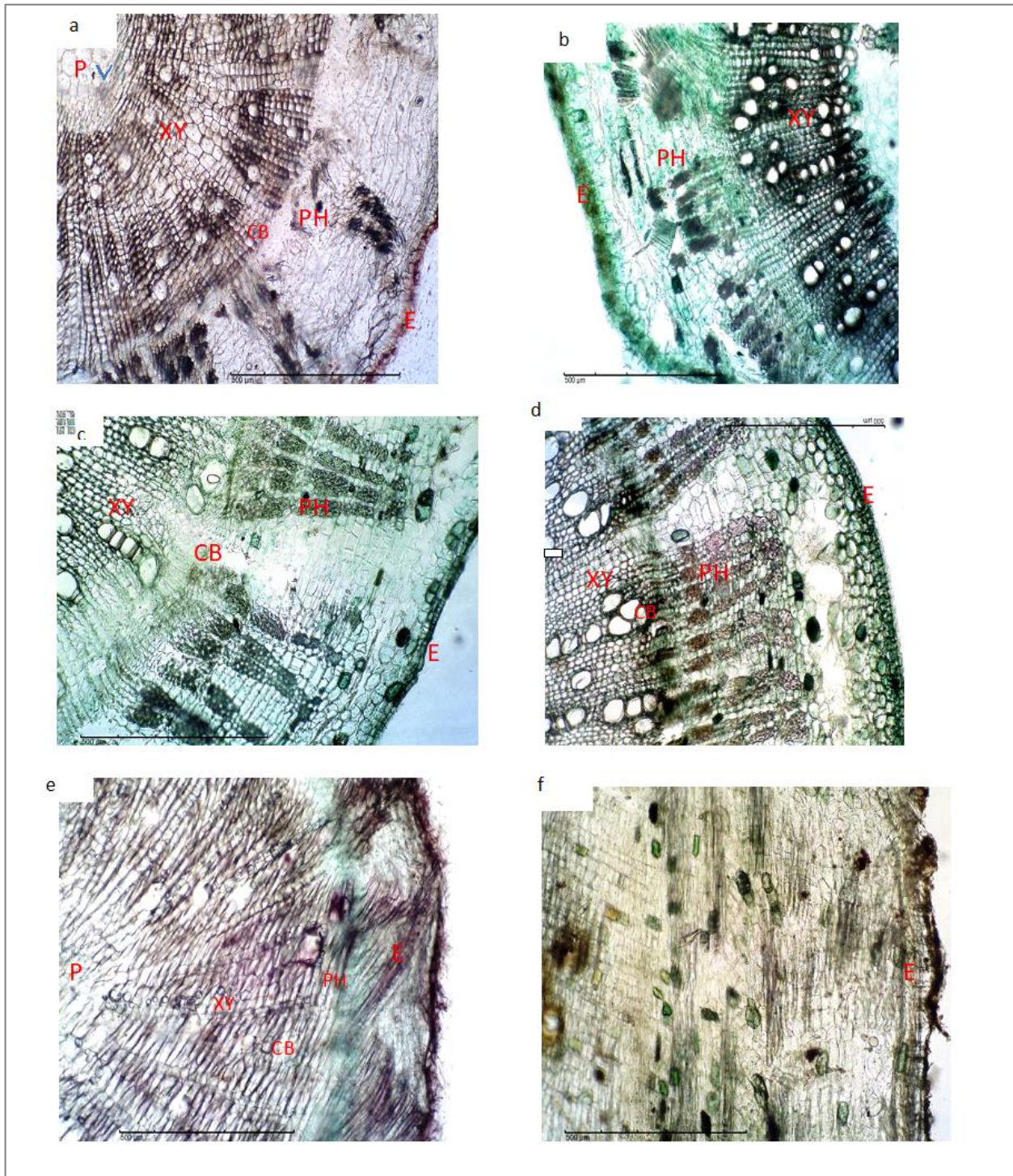


Plate 3: Transverse sections of root *C. olitorius*: 0% (control) (10a), 20% treatment (10b), 40% treatment (10c), 60% treatment (10d), 80% treatment (10e), and 100% treatment (10f). P= Pith, XY= Xylem, PH= Phloem, E= Epidermis, CB =Cambium

DISCUSSION

Transverse sections of the leaves of *C. olitorius* irrigated with ICE showed variations in the shapes and forms of internal tissues, such as phloem, cambium, pith, and xylem, across all treatments. Furthermore, high levels of ICE concentrations (60%–100%) distorted the single-layered outline of the leaves. However, there was no

observable difference at lower treatment levels (0% to 40%). Similarly, higher effluent levels reduced xylem cells compared to lower levels. These abnormalities in plant tissues could be attributed to the level of toxicity and the high osmotic potential of the ICE concentrations used. The largest xylem vessel diameter was observed in the 0% ICE treatment, followed by 40% ICE, whereas at the

higher concentration (100% ICE) vessels were not discernible.

Transverse sections of the stem of *Corchorus olitorius* showed that at higher concentrations, the epidermis was distorted, whereas tissues such as phloem, cambium, and pith were intact in all treatments. The ICE showed a significant toxic effect on the xylem vessels of the *Corchorus olitorius* stem, as evidenced by reduced vessel diameter in plants treated with higher levels of the effluent. Treatment with 40% ICE had the highest number of vessels with a diameter, possibly due to its lower toxicity, whereas at higher concentrations (80% - 100%) vessel diameter was significantly reduced. This is in accordance with [Ogunkule et al. \(2013\)](#) who reported similar findings in *A. hybridus* irrigated with pharmaceutical effluent.

The proliferation of xylem vessels in the root of *Corchorus olitorius* was promoted at a very low concentration of ICE. Still, its toxic effect resulted in a sequential reduction in vessel diameter in the 20%-60% treatment groups. The progressive toxic effects of ICE reduce the diameter of the vessels in the root. This was also reported by [Mahmood et al. \(2005\)](#) and [Tyag et al. \(2012\)](#), who tested the effect of industrial effluent on water hyacinth and *Chenopodium album*, respectively, and reported a reduction in vessel diameter at higher concentrations. However, 80% and 100% treatment were distorted and appeared difficult to study, probably due to the effluent's extreme toxicity, which agrees with the work of [Ogunkule et al. \(2013\)](#).

CONCLUSION

Anatomical analysis showed that irrigation of *Corchorus olitorius* L. with ICE at concentrations $\geq 60\%$ caused distortion of the leaf outline, epidermis, and xylem vessels, whereas 0-40% ICE caused minimal damage. The reduction in vessel diameter and number with increasing ICE concentration indicates phototoxic effects, likely due to heavy metals and high osmotic potential. Based on this finding, *C. olitorius* can serve as a bioindicator of effluent pollution. However, using ICE at concentrations above 40% for irrigation is not recommended, as it compromises plant structural integrity.

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